cee1: Civil Engineering & Infrastructure

syllabus + an introduction

by

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UCLA

Syllabus

Course Description

This is a seminar series designed to expose undergraduate students (freshmen) to recent research activities and state-of-the-art practice in various civil engineering sub-disciplines, and to familiarize them with CEE curriculum.

Prerequisites

None

Attendance

Attendance Attendance will be taken weekly. Please attend each week & complete the online attendance sheets that will be made available at CCLE prior to every seminar. It will be your responsibility to mark your attendance for every seminar you have attended.

Syllabus

Quizzes

Online quizzes on basic concepts presented in the seminars will be given weekly.

Grading basis

P/NP based on outside work, quiz scores, and attendance. Passing marks are required on outside work plus > 80% attendance and > 50% on quizzes to secure a "P" grade.

Work outside class

Complete project tasks organized by student societies. Project details and sign up here: http://www.ascebruins.org/cee-1.html

More details on work outside class

1. Attend at least one of the **workshops** that ASCE's various engineering projects will put on throughout Fall Quarter. Workshops will vary in duration and will cover a variety of topics that include, but are not limited to, concrete materials, construction management, water resources, geotechnical engineering, structural engineering, and surveying.
    - expose you to the different paths available within the broad field of civil engineering
    - provide valuable hands-on experience the projects can offer.
2. Complete UCLA's online **Lab Safety Fundamentals Training** course within the first two weeks of class prior to signing up for the workshop(s). The course is available at worksafe.ucla.edu. Submit **Certificate of Completion** during the sign up process to the workshop(s).
    - provide preparation and properly training to operate in labs, shops, and lab spaces.
3. Attend at least **one professional development event**. Events will include company information sessions, field trips to various sites, job shadowing of professionals, career development workshops, and ASCE's Fall Career Fair.
    - provide experiences into the real world of civil engineering,
    - learn about what companies do
    - network with industry professionals.
4. Submit a **two-paragraph response** outlining what was learned and gained from each experience upon completion of all the aforementioned requirements.
    - one for the workshop attended
    - one for the professional development event attended

Syllabus

Schedule

Week	Date	Speaker	Topic
1	24 Sep	Prof. Taciroglu	Course overview ++
2	1 Oct	Prof. Zhang	CEE curriculum
3	8 Oct	ASCE UCLA, EWB, ITE, CalGeo, EERI, $\chi\epsilon$	Student organizations
4	15 Oct	Peter Behnam	Structural Engineering
5	22 Oct	Rudolph Bonaparte (Drag Lecture)	Climate Change Mitigation
6	29 Oct	Prof. Jay & Ileana Callehas	Environmental Engineering
7	5 Nov	tbd	Alumni Panel
8	12 Nov	tbd	Hydrology Water Res. & Coastal Eng.
9	19 Nov	tbd	Transportation Engineering
10	26 Nov	Thanksgiving holiday (no seminar)	
11	3 Dec	tbd	Geotechnical Engineering

Some Stats & Facts

UCLA — by the numbers

Ranked as the #1 Public University (WSJ, US News)

Record 168,000 freshmen & transfer students applied to UCLA for Fall 2021

31,600
Undergraduate Students

14,300
Graduate & Professional Students

5,400
International Students

7,790
Faculty Members

118
Countries Represented By Students

31%
First-Generation Undergraduates

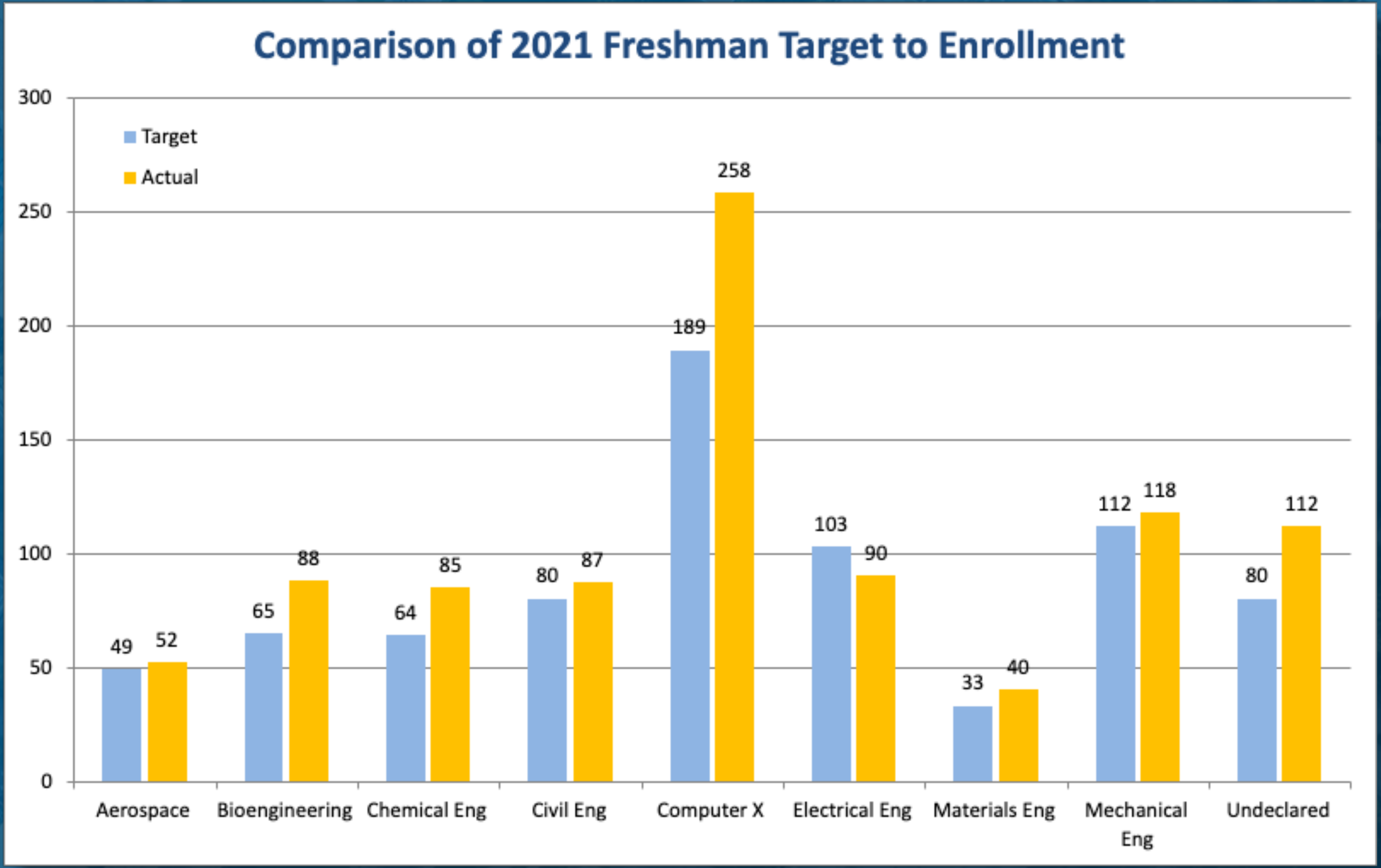
10%
International Undergraduates

34%
Undergraduates Receive Pell Grants

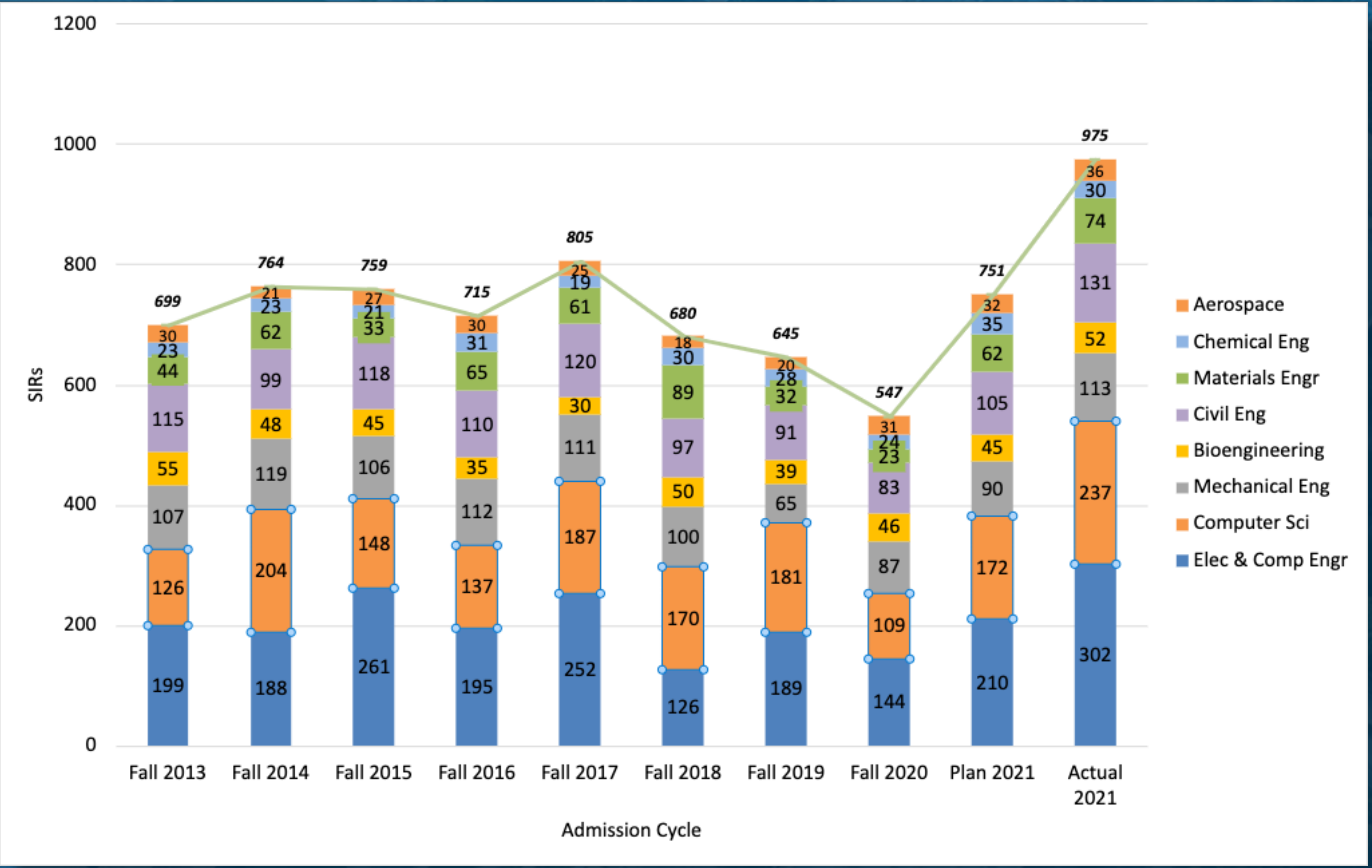
UCLA Samueli

5,100 students

UCLA Engineering

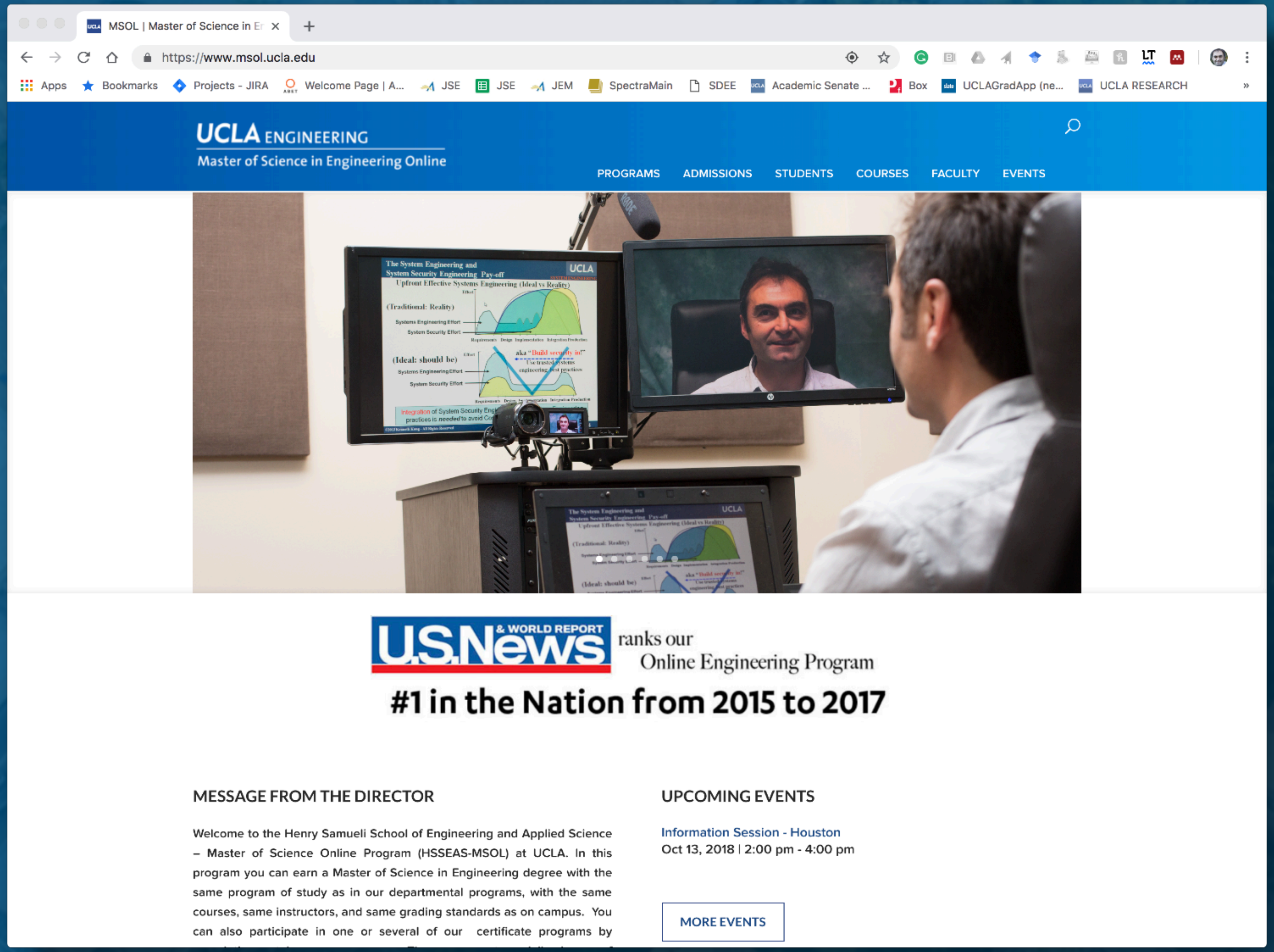


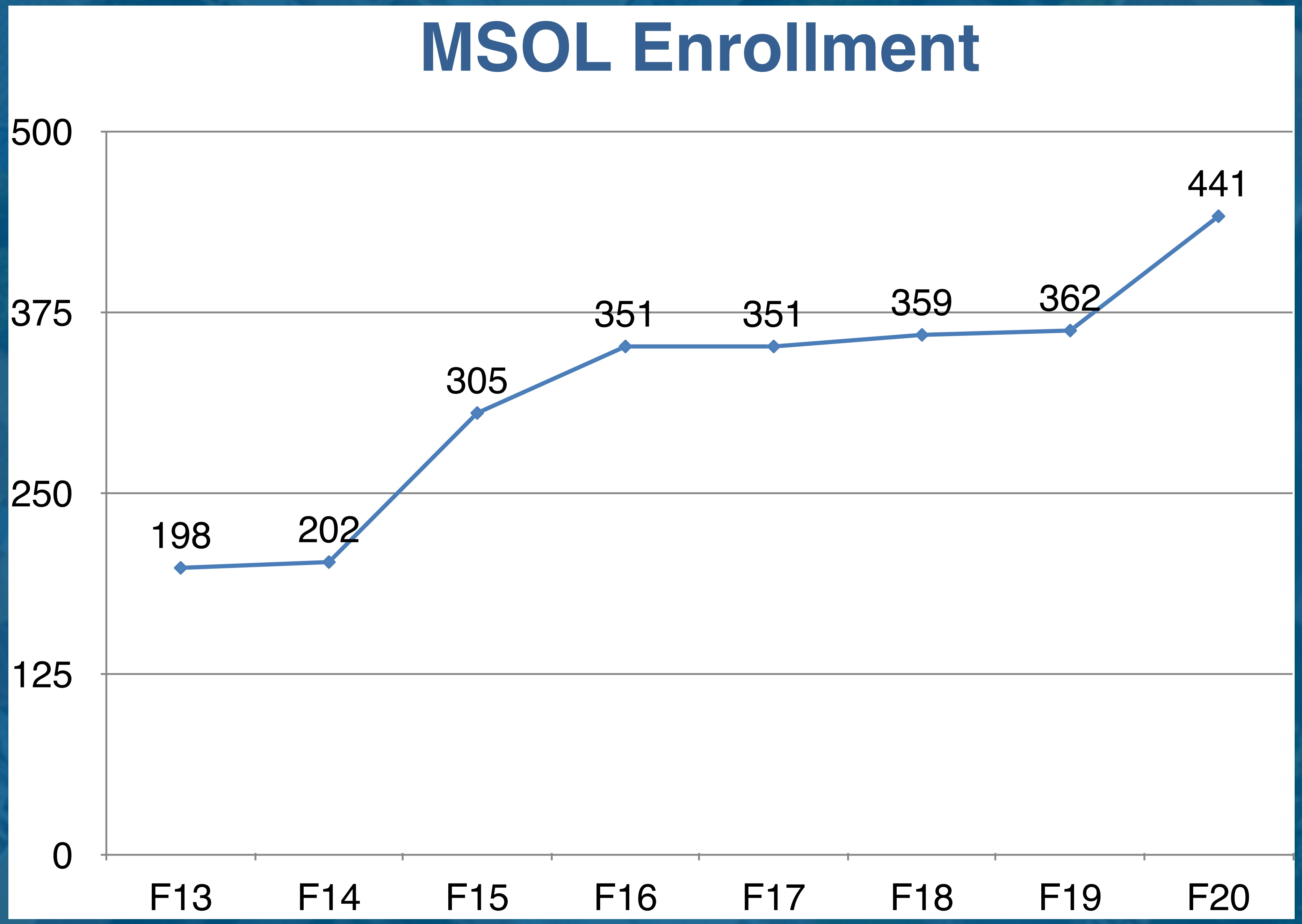
UCLA Engineering



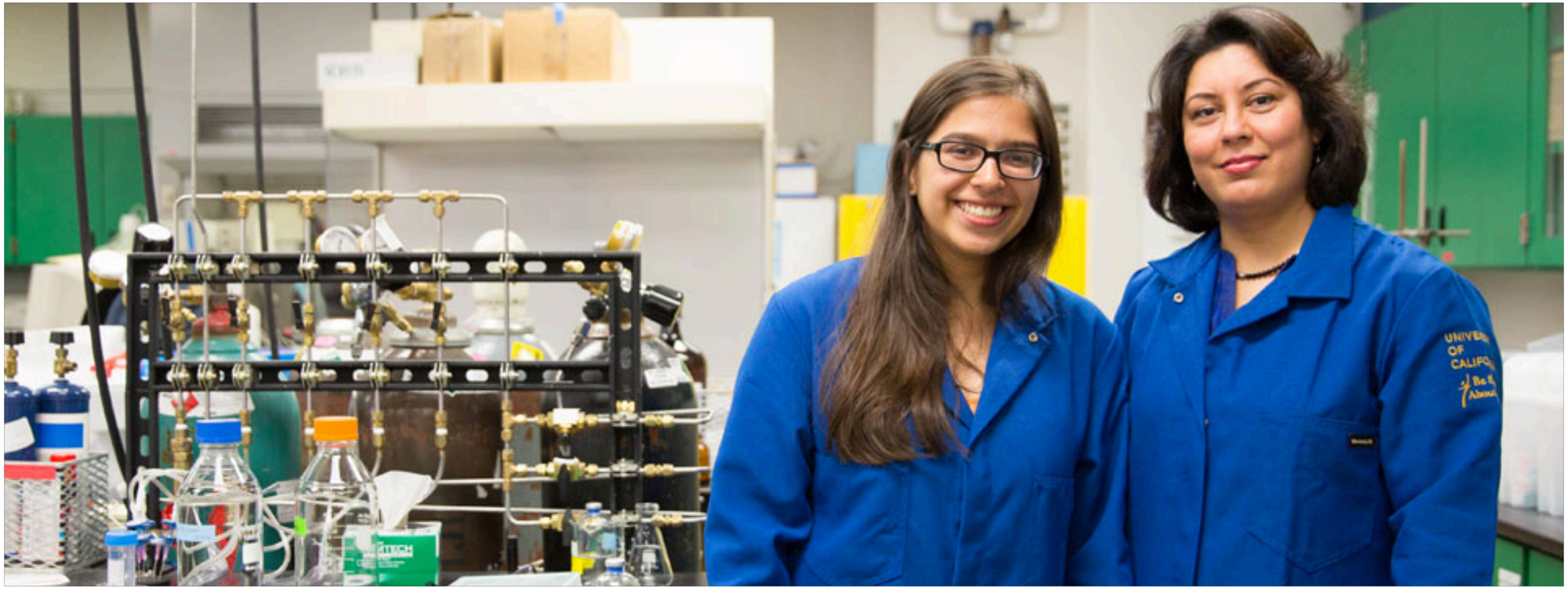
UCLA Civil & Environmental Engineering Department

UCLA Engineering





CEE — by the numbers



Undergraduate acceptance rate = ~12% (201 over 1620)

Undergraduate Enroll/Accept = ~44% (88 over 201) << Highest in Samueli

High School median GPA = 4.5W (4.0U)

CEE — by the numbers

24 + 2 ladder, 3 joint, and 7 adjunct faculty, 2 active emeriti, 7-1 staff

~320 undergraduate students (BS), ~200 graduate students (MS, PhD)

Student/Faculty = 9, % Female students > 30%

CEE — by the numbers

PhD students graduating per year = ~1/faculty

Publications: median indices: h = 25, i_{10} = 50, 250 papers in 2018 (10/faculty)

External research grants: average = $300K/year/faculty (est.)

Aerospace #12

Bioengineering #30

Chemical #23

Electrical #13

Material #23

Mechanical #14

BEST
U.S.News
RANKINGS

Rank	School	Score
1	University of California--Berkeley	4.6
1	University of Illinois--Urbana-Champaign	4.6
3	Georgia Institute of Technology	4.5
3	Stanford University (CA)	4.5
5	University of Texas--Austin (Cockrell)	4.4
6	Purdue University--West Lafayette (IN)	4.2
7	Massachusetts Institute of Technology	4.1
7	University of Michigan--Ann Arbor	4.1
9	Virginia Tech	4.0
10	Carnegie Mellon University (PA)	3.9
10	Northwestern University (McCormick) (IL)	3.9
12	Cornell University (NY)	3.8
12	University of California--Davis	3.8
14	California Institute of Technology	3.7
14	Texas A&M University--College Station	3.7
16	Princeton University (NJ)	3.6
16	University of California--Los Angeles (Samueli)	3.6
16	University of Minnesota--Twin Cities	3.6
16	University of Washington	3.6
16	University of Wisconsin--Madison	3.6
21	Pennsylvania State University--University Park	3.5
21	University of California--San Diego (Jacobs)	3.5

2021 CEE Rankings #16 (US)

8 + 1 NSF CAREER Award Winners, 7 ASCE W. Huber Research Prize Winners

4 National Academy of Engineering Members

CEE Student Groups

ASCE STUDENT CHAPTER UNIVERSITY OF CALIFORNIA LOS ANGELES

UCLA CalGeo Student Chapter

California Geotechnical Engineering Association

Chi Epsilon

ENGINEERS WITHOUT BORDERS USA
UNIVERSITY OF CALIFORNIA, LOS ANGELES
STUDENT CHAPTER

INSTITUTE OF TRANSPORTATION ENGINEERS
AT UNIVERSITY OF CALIFORNIA, LOS ANGELES

EERI

Earthquake Engineering Research Institute

swe

Society of Women Engineers

Tau Beta Pi The Engineering Honor Society

ite at UCLA

GEO-STR-HWR-ENV-MAT-*TRANSP*

Geotechnical Engineering Faculty

Scott J. Brandenberg, Professor

Jonathan P. Stewart Professor and Chair

Mladen Vucetic Professor

Youssef Bozorgnia, Professor

Macan Doroudian, Lecturer, Exponent

Rob Kayen Adjunct Professor, Research Civil Engineer USGS

George Mylonakis Adjunct Professor, Professor University of Bristol

Suji Somasundaram Lecturer, Principal Engineer, Advanced Earth Sciences

Marty Hudson Lecturer, AMEC Foster Wheeler

Jennifer Donahue, Lecturer, GeoSyntec

GEO Undergraduate Courses

CEE 120: Principles of Soil Mechanics

CEE 121: Design of Foundations and Earth Structures

CEE 123: Advanced Geotechnical Design

CEE 125: Fundamentals of Earthquake Engineering

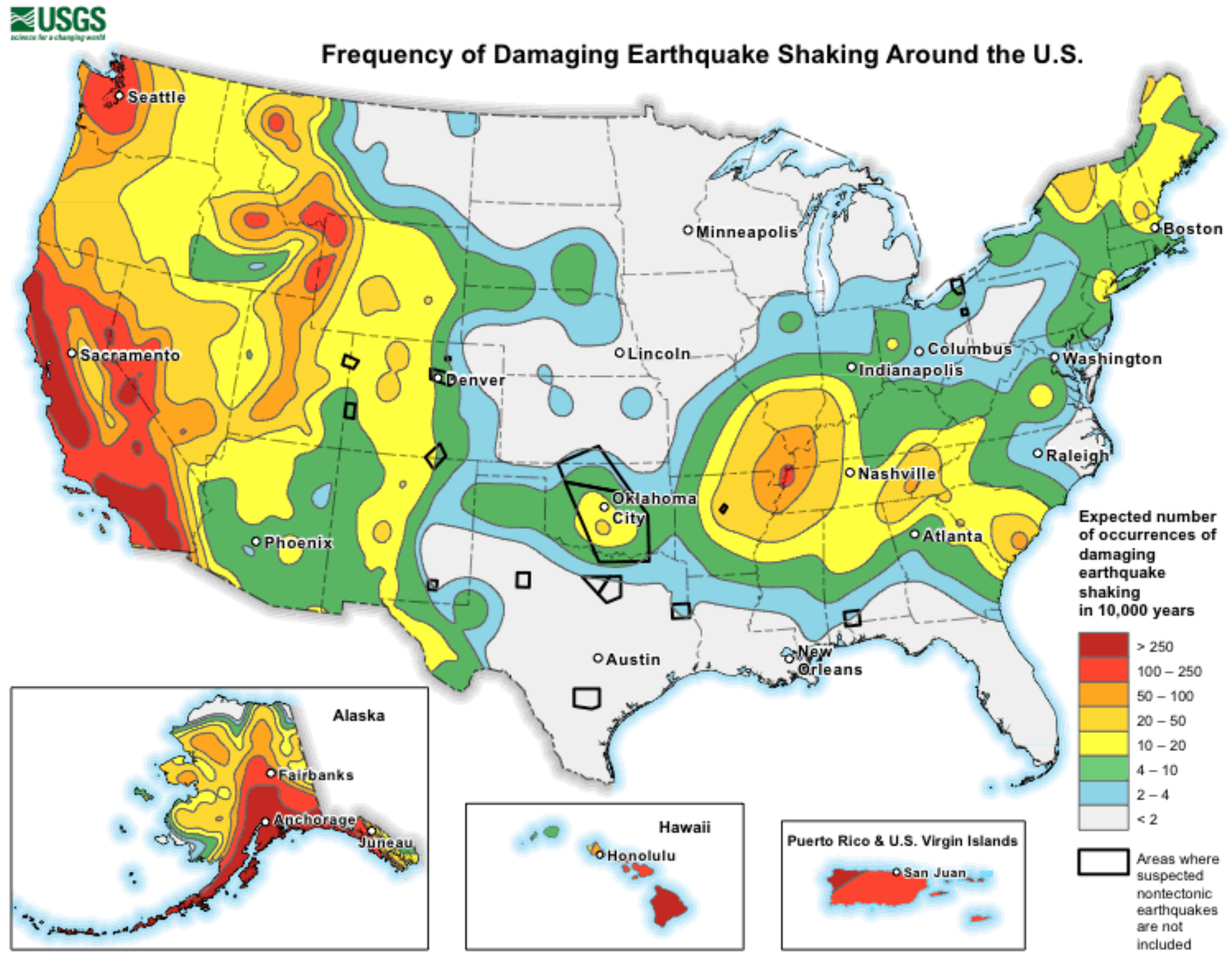
CEE 128L: Soil Mechanics Laboratory

CEE 129L: Engineering Geomatics

GEO Research Examples

Earthquake Ground Motion Characterization

- Public databases of ground motions and metadata
- Models to predict ground shaking intensity at global scale
- Used in USGS National Maps, building codes, and high-value site-specific applications
- Sponsors: USGS, CEA, CSMIP, utilities, Caltrans, insurance



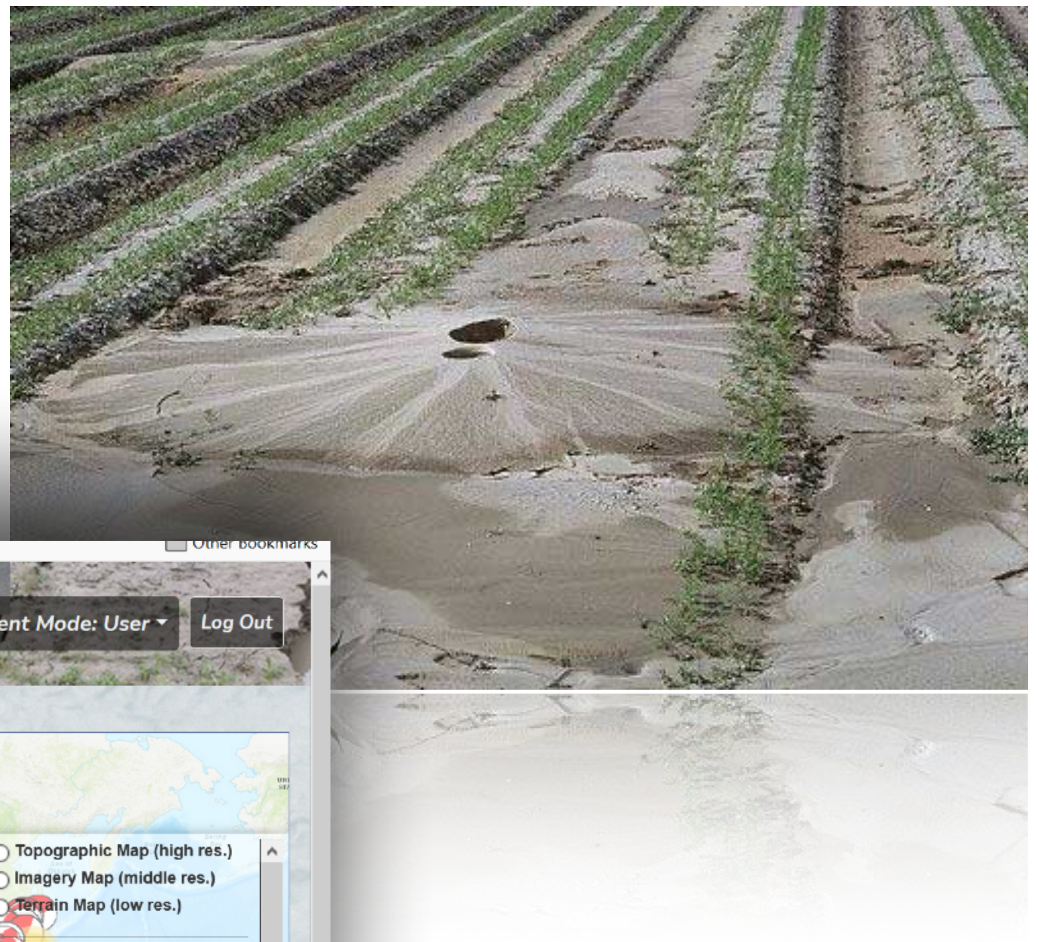
GEO Research Examples

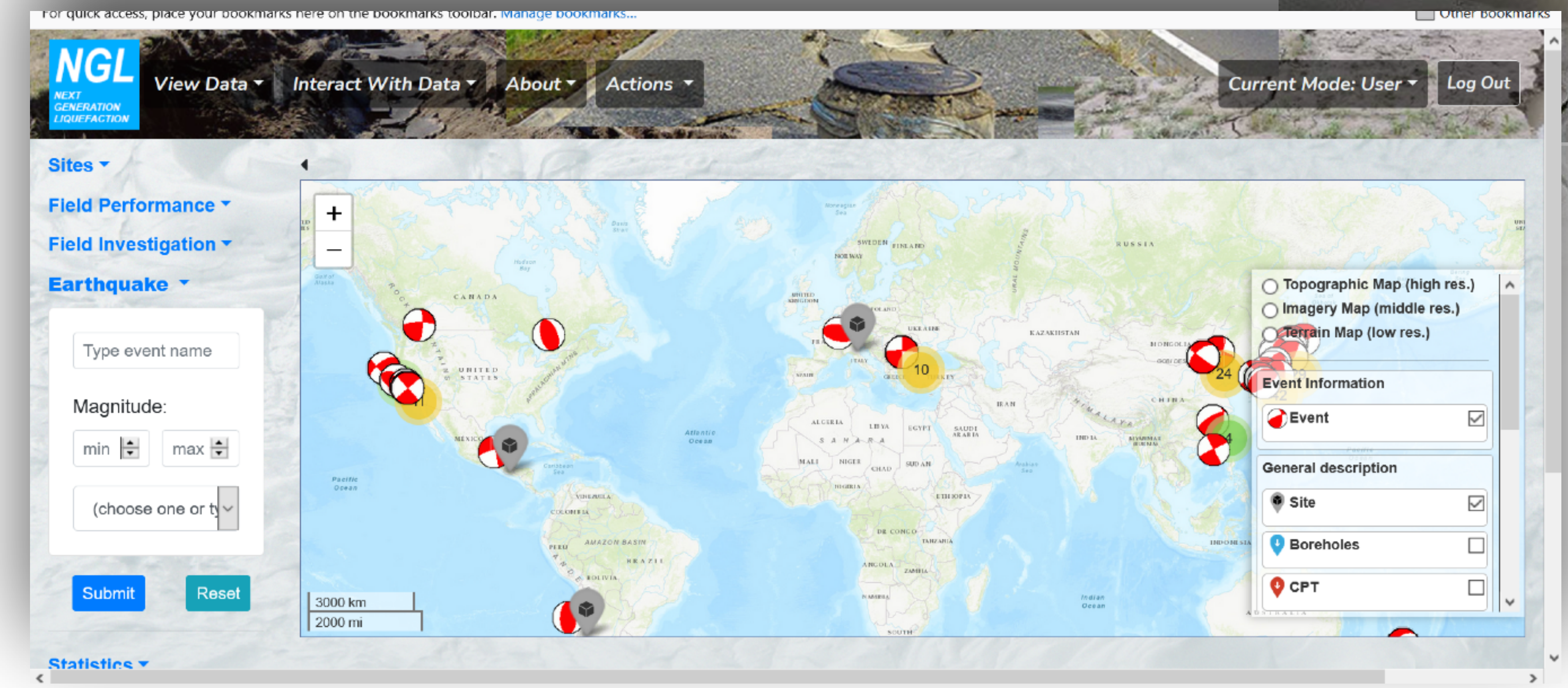
Seismic Performance of Levees

- Fragility models from simulations and field performance data
- Calibrated risk-based system performance
- Site response for peaty organic soils in CA Bay-Delta region
- Sponsors: CA-DWR

Soil Liquefaction

- Leadership of NGL Project
- Engagement of stakeholders & topical experts
- Global database of field performance case histories
- Next-generation, high-impact models
- Sponsors: USBR, US-NRC, Caltrans, PEER, NHR3





HWR Faculty

Urban coastal flood prediction, Wave run-up and overtopping, Coastal hazards, Sea level rise, Flood control infrastructure and mitigation methods

Timu Gallien

Hydrologic remote sensing; Uncertainty analysis; Water resource management and governance; International water resource development.

Mekonnen Gebremichael

Surface hydrology, hydrometeorology, remote sensing, and data assimilation.

Steve Margulis

Groundwater hydrology, modeling of solute transport in groundwater, optimization of water resources systems.

William Yeh

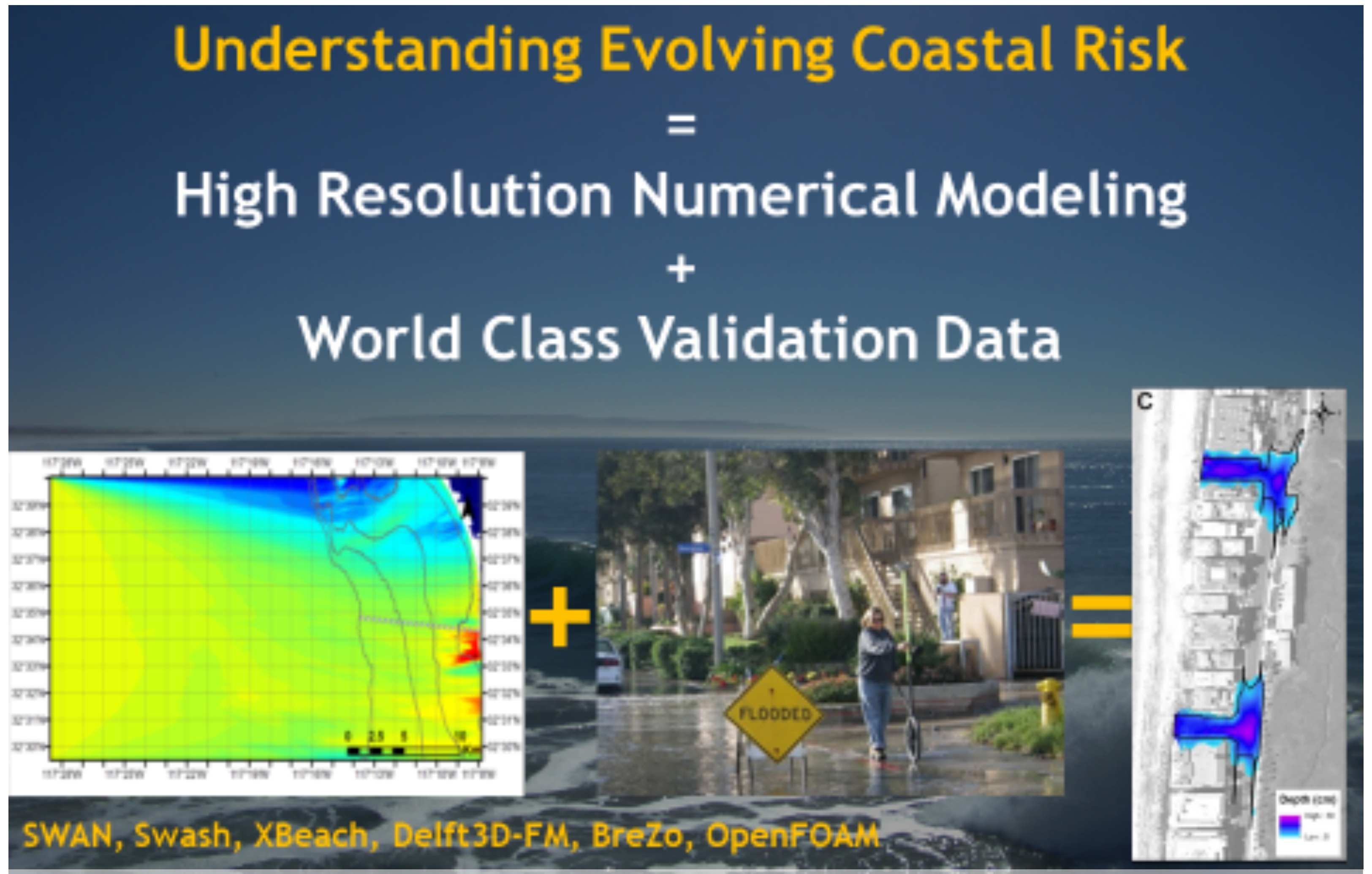
Adjunct Faculty: Teaching interests in hydraulic and hydrologic design, water resources planning

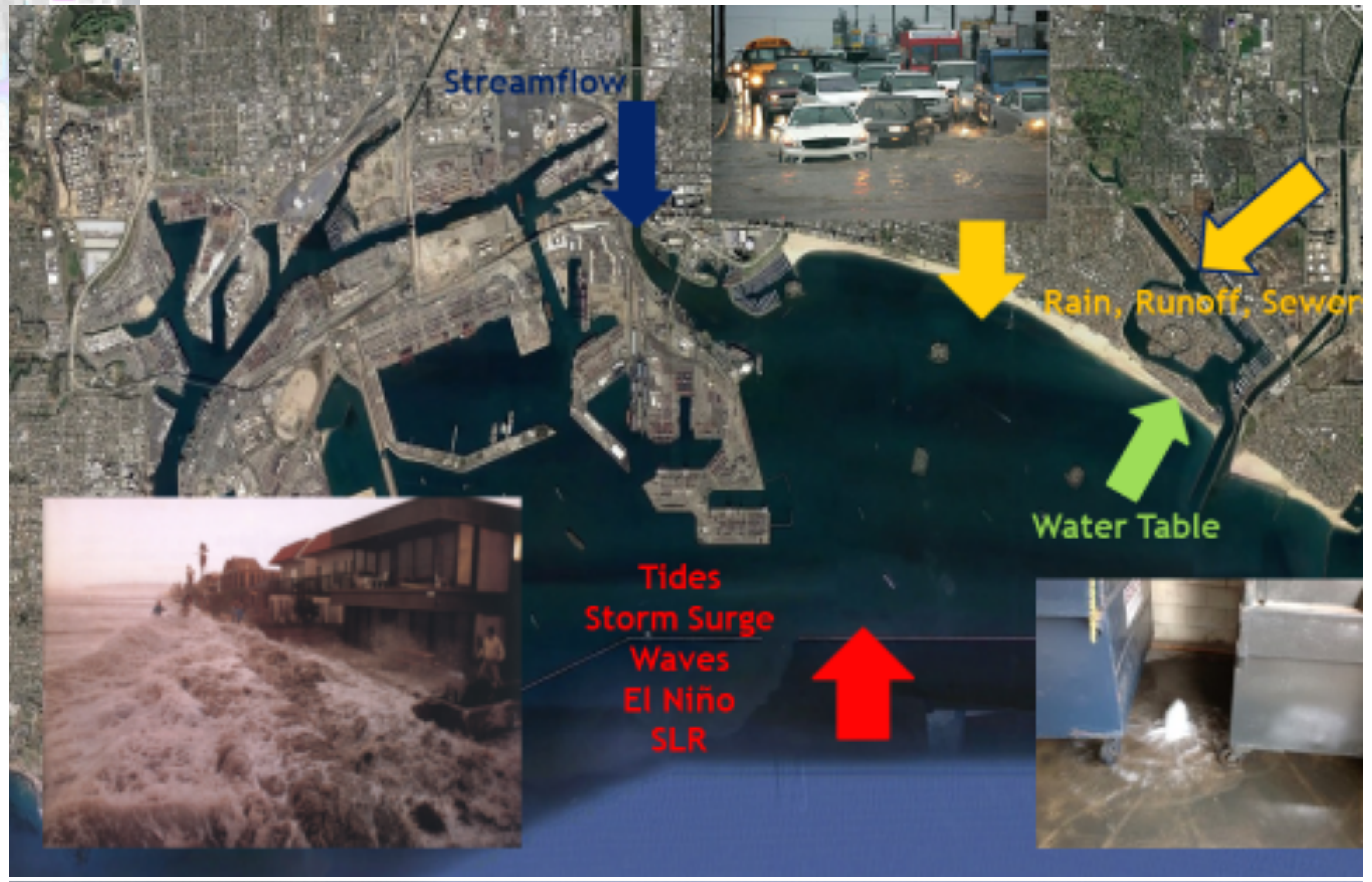
Don Kendall

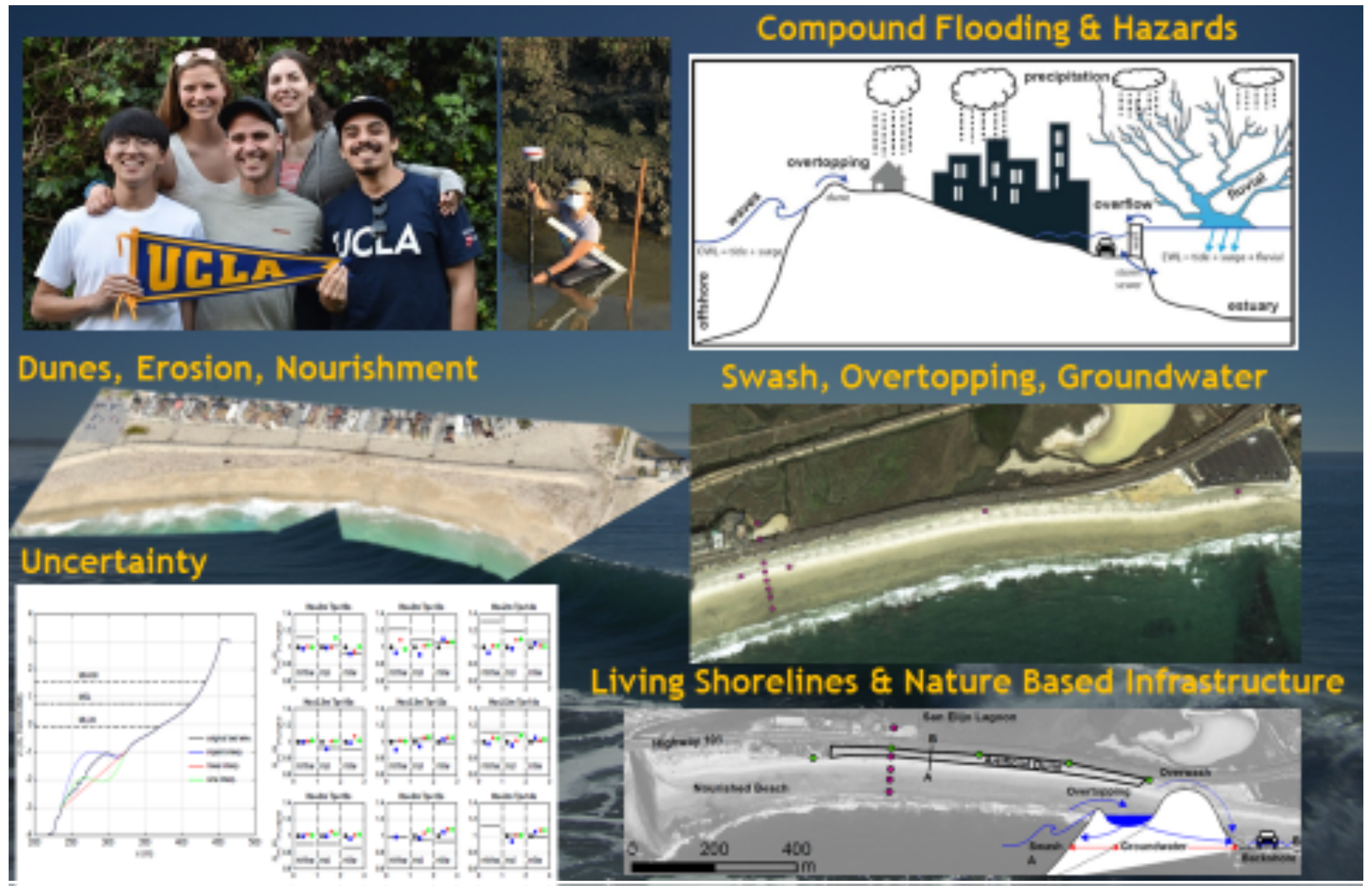
Joint Appointment with Dept. of Geography: Land surface hydrology; hydroclimatology

Dennis Lettenmaier

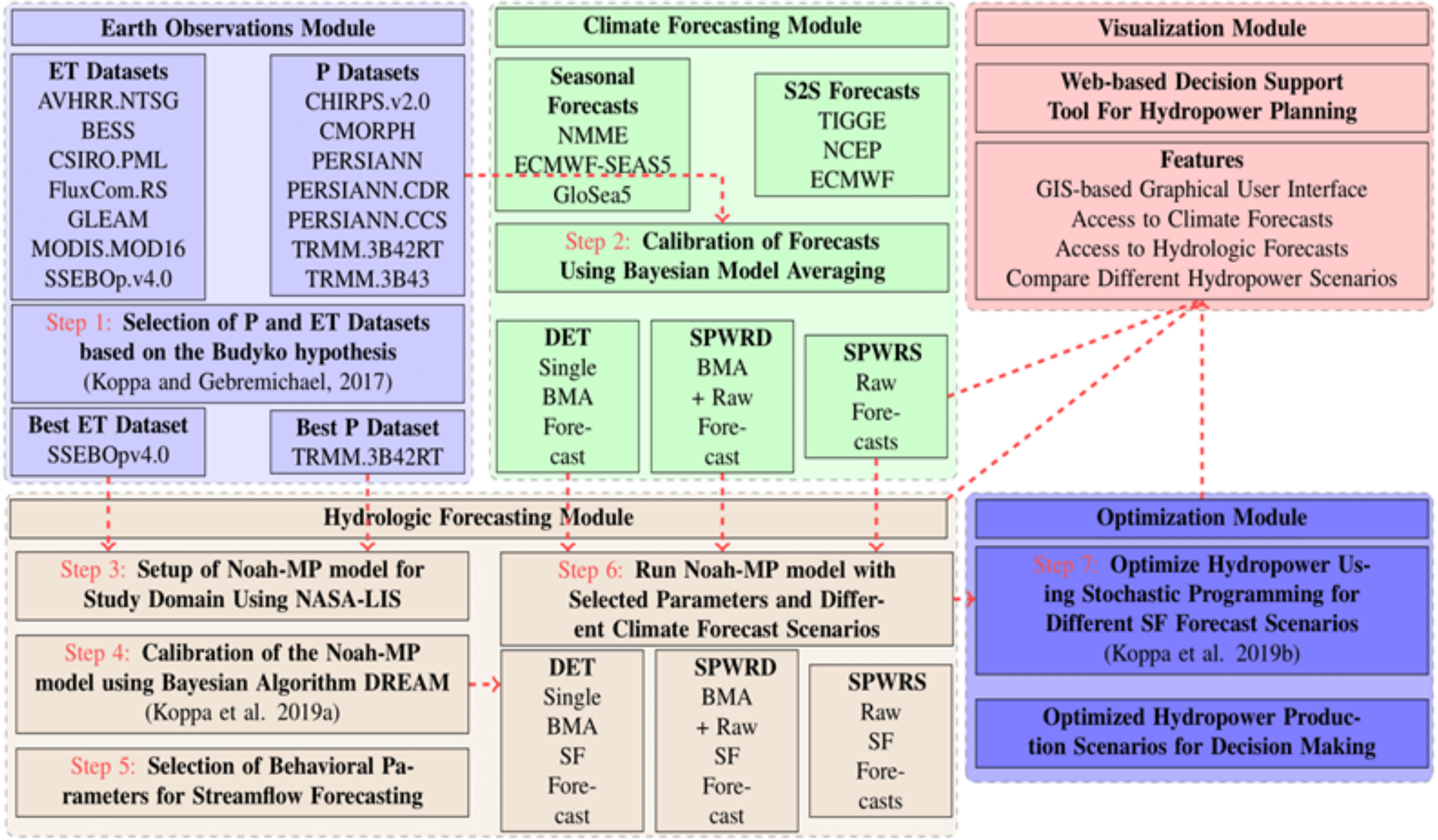
Gallien Research Group (Highlights)

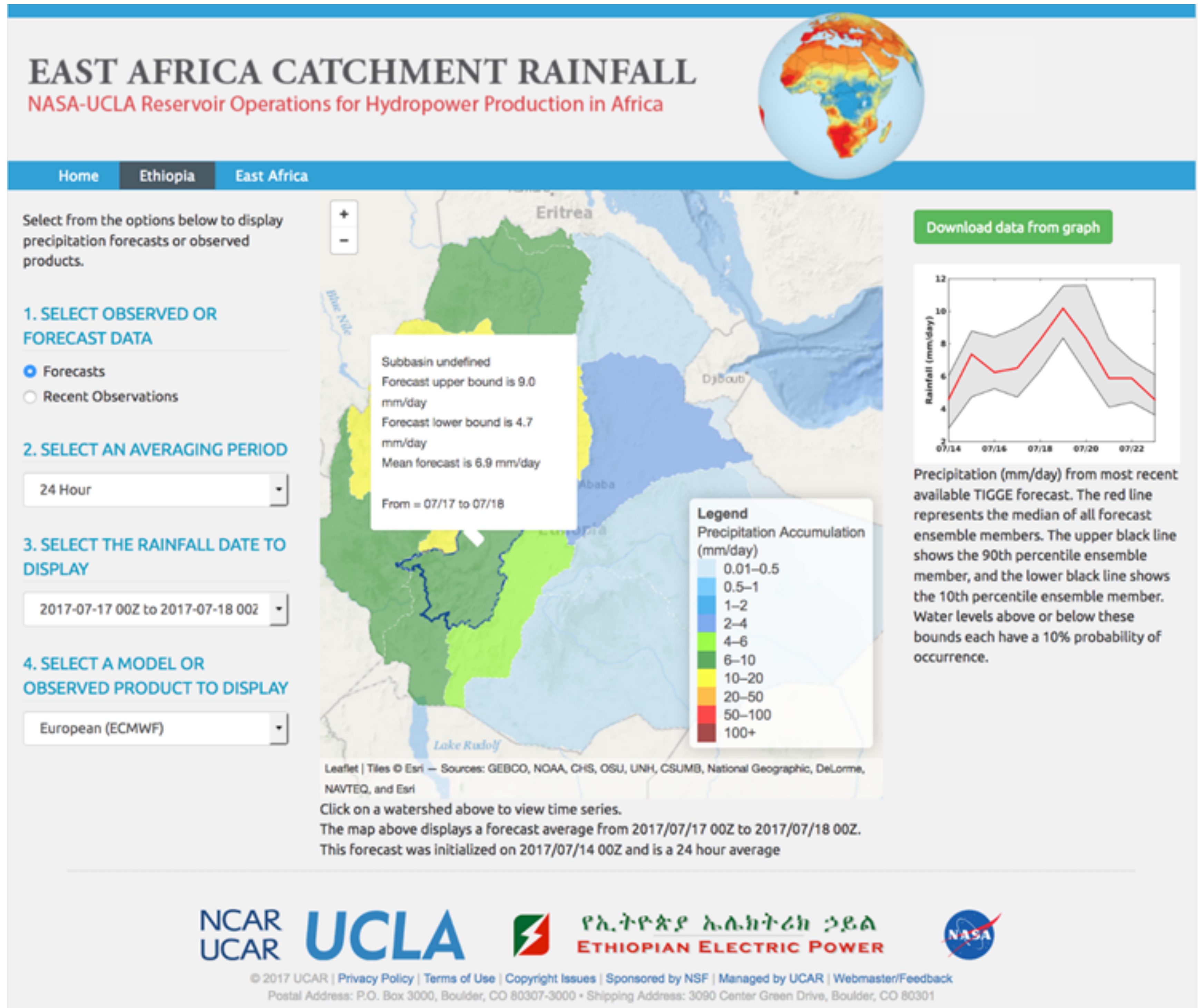






Development of decision support system for hydropower reservoir operation in Africa





Development of new methods for estimating snow-derived water resources

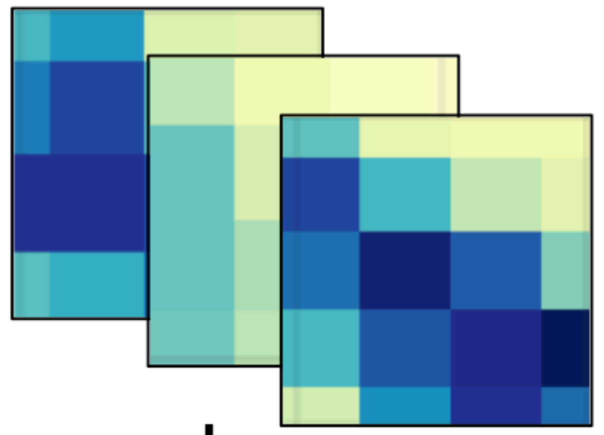
New large-scale sets

("big data")

Meteorological forcing

(Precip., air temp., radiation, etc.)

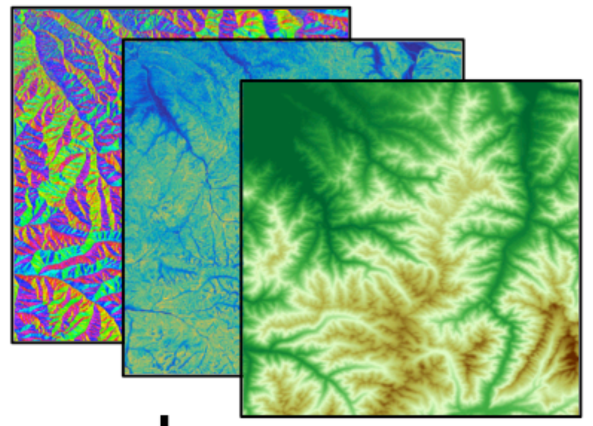
e.g. NLDAS-2, MERRA-2



Topographic data

(DEM, slope, aspect, etc.)

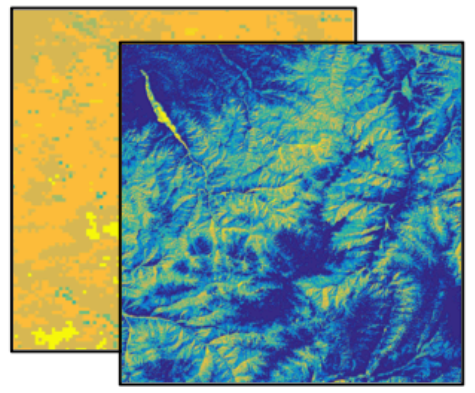
e.g. SRTM, ASTER



Landcover data

(landcover, forest cover fraction, etc.)

e.g. NLCD, MODIS



Numerical modeling

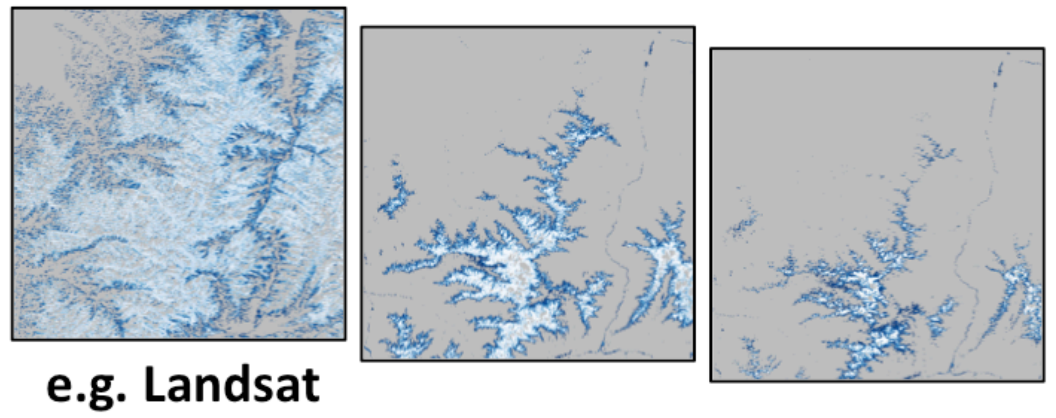
Forcing downscaling/uncertainty
(Girotto et al., 2014; Cortés et al., 2016)

Resampling to uniform or multi-resolution model grid
(Baldo and Margulis, 2017)

Generation of prior (open-loop) estimates
- Parameter uncertainty
- Land Surface Model-Snow Depletion Curve [LSM-SDC]
- Prior fSCA/SWE and other snow-related estimates

Satellite-based remote sensing data

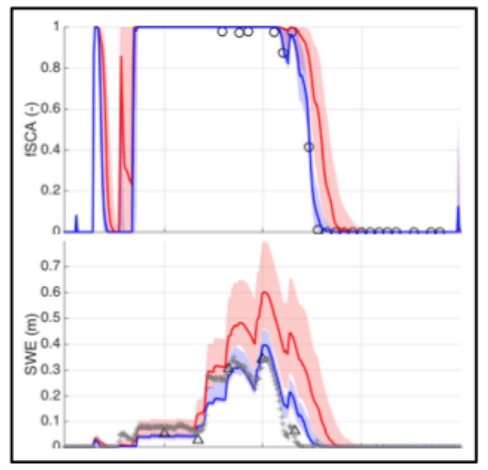
Fractional Snow Covered Area (fSCA) Observations (Cortés et al., 2014)

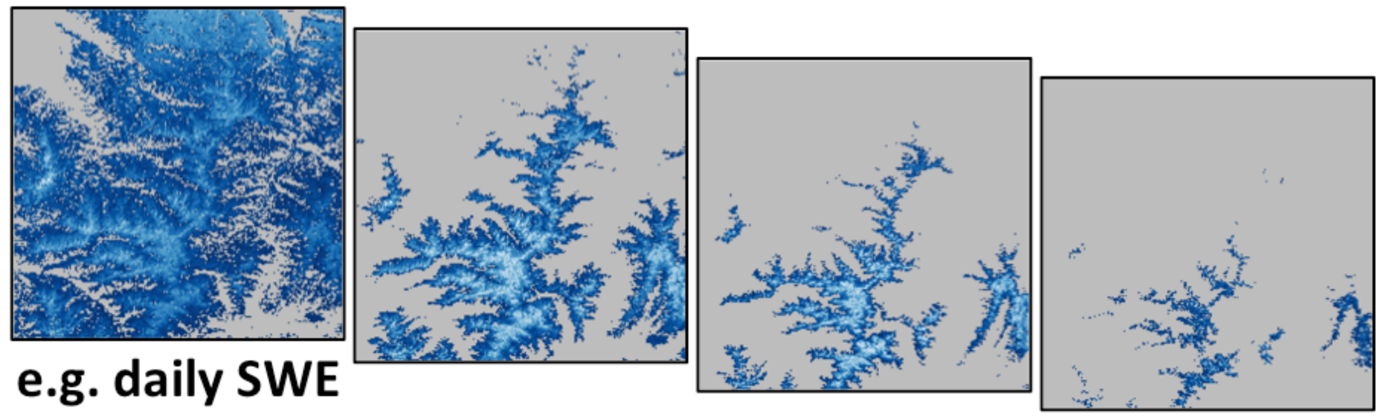


e.g. Landsat

Probabilistic Estimation

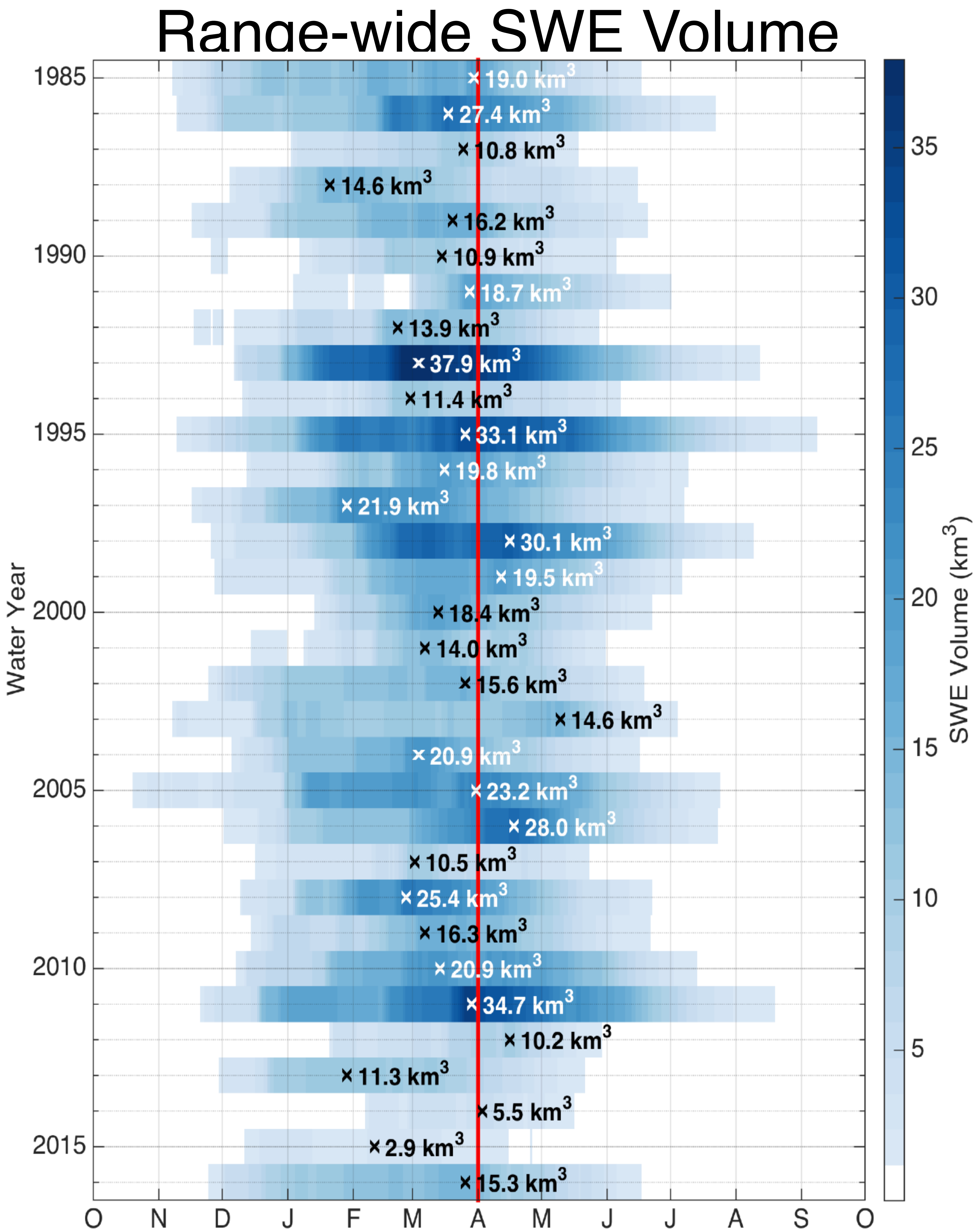
Reanalysis step
- Bayesian update; condition prior estimate on remotely-sensed fSCA
- Using Particle Batch Smoother (PBS; Margulis et al., 2015)
- Posterior SCA/SWE and other snow estimates (along with posterior parameters/forcings)

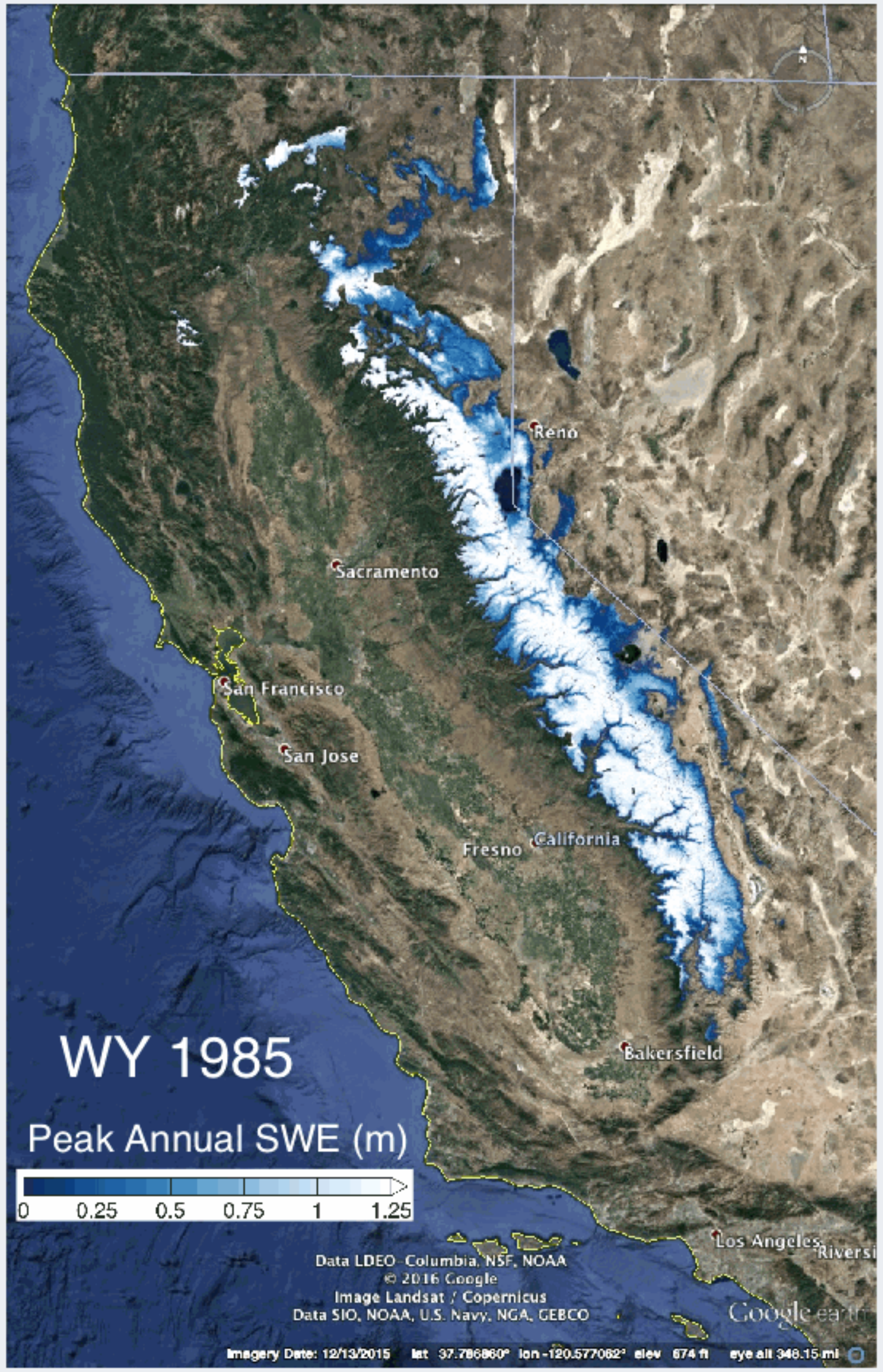




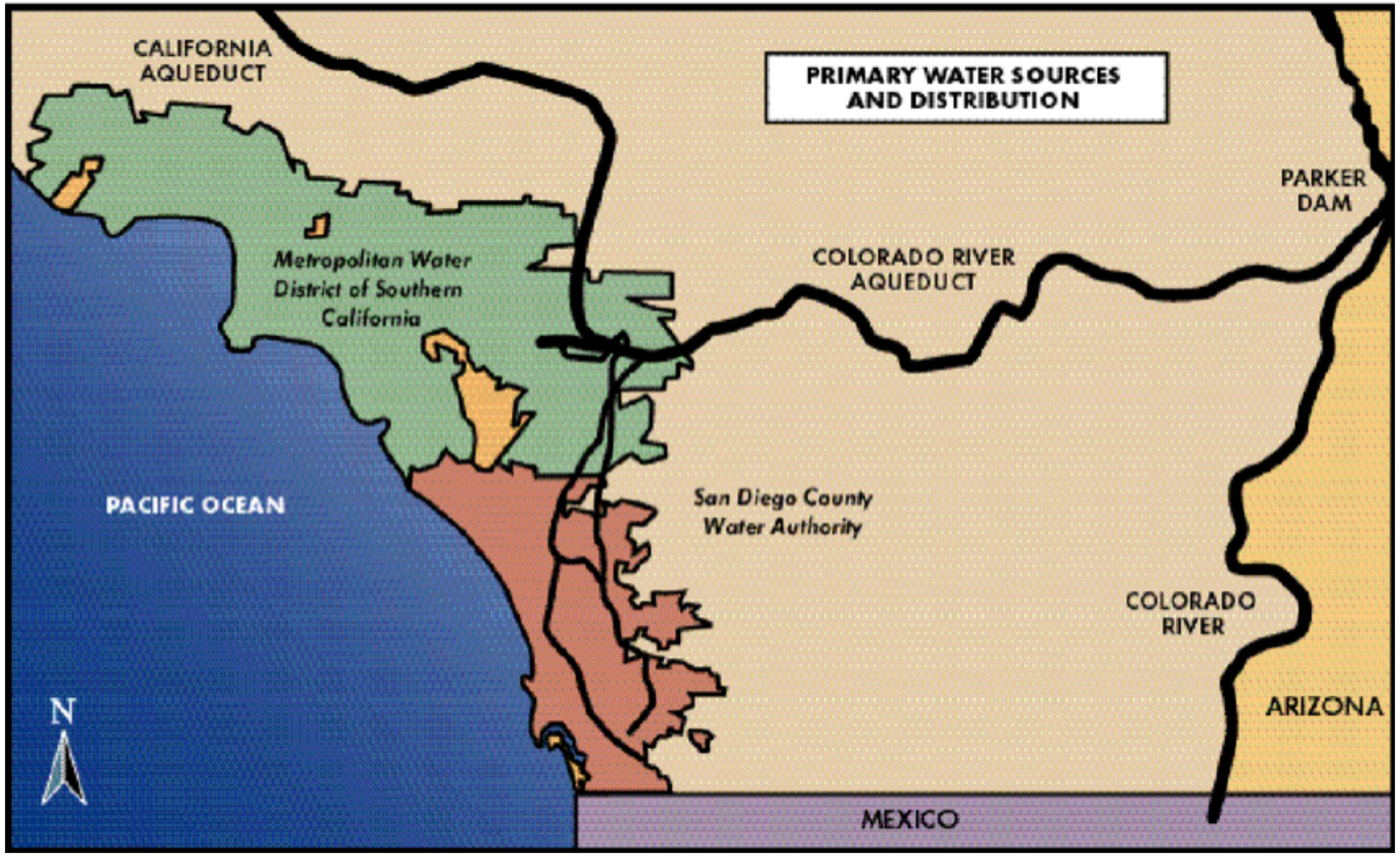
e.g. daily SWE

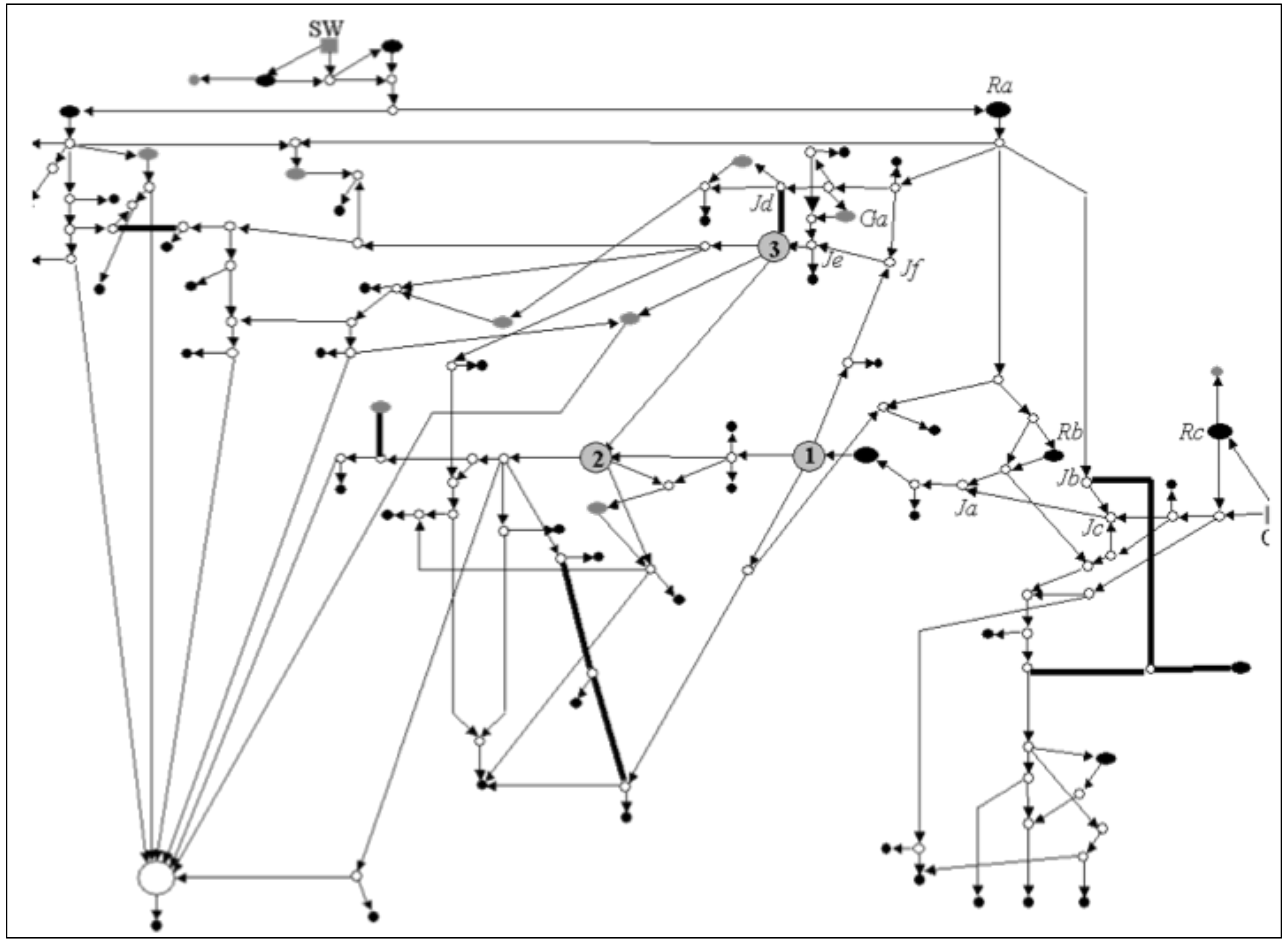
California Snow-derived Water Resources



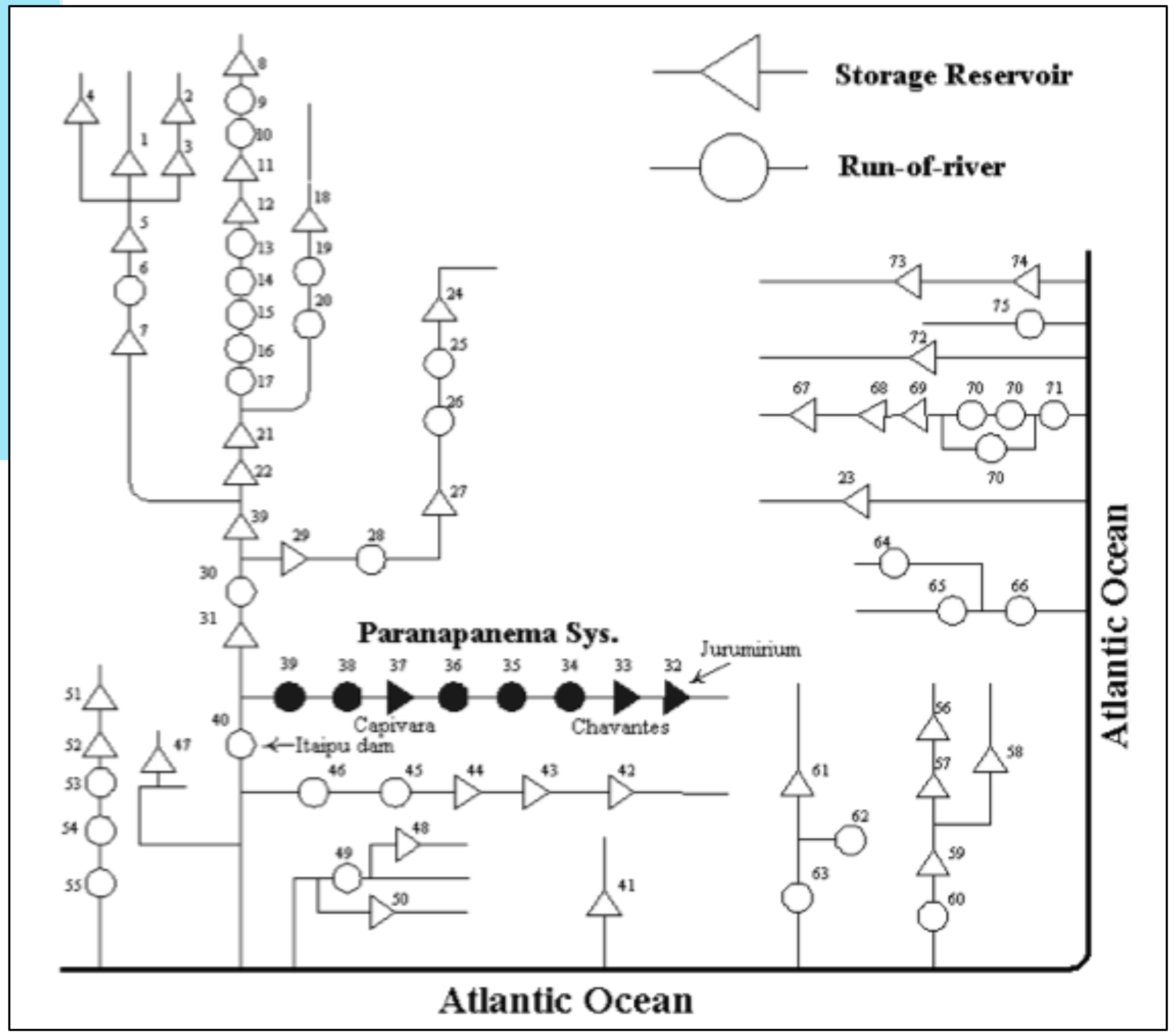


Metropolitan Water District (MWD) System Modeling and Optimization

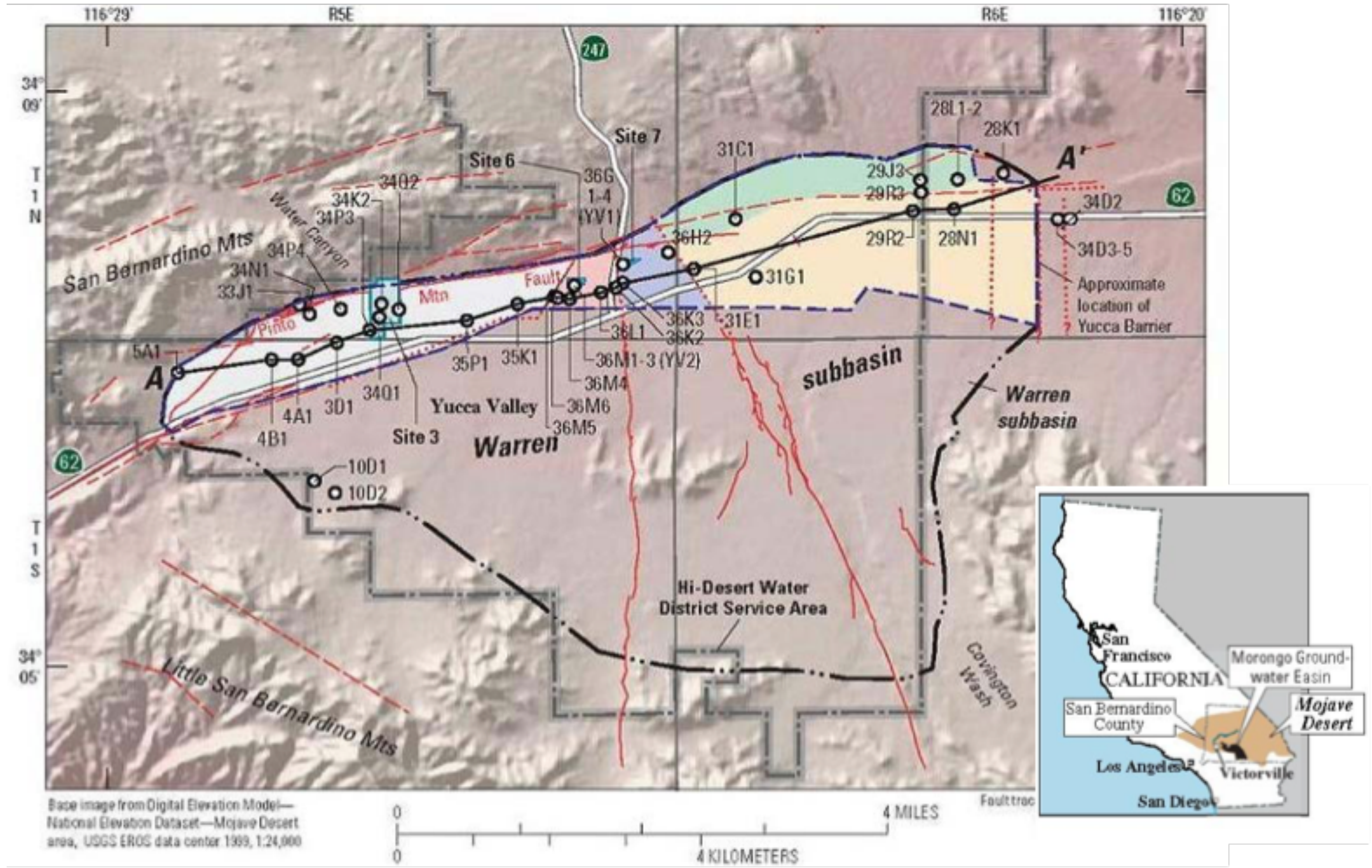


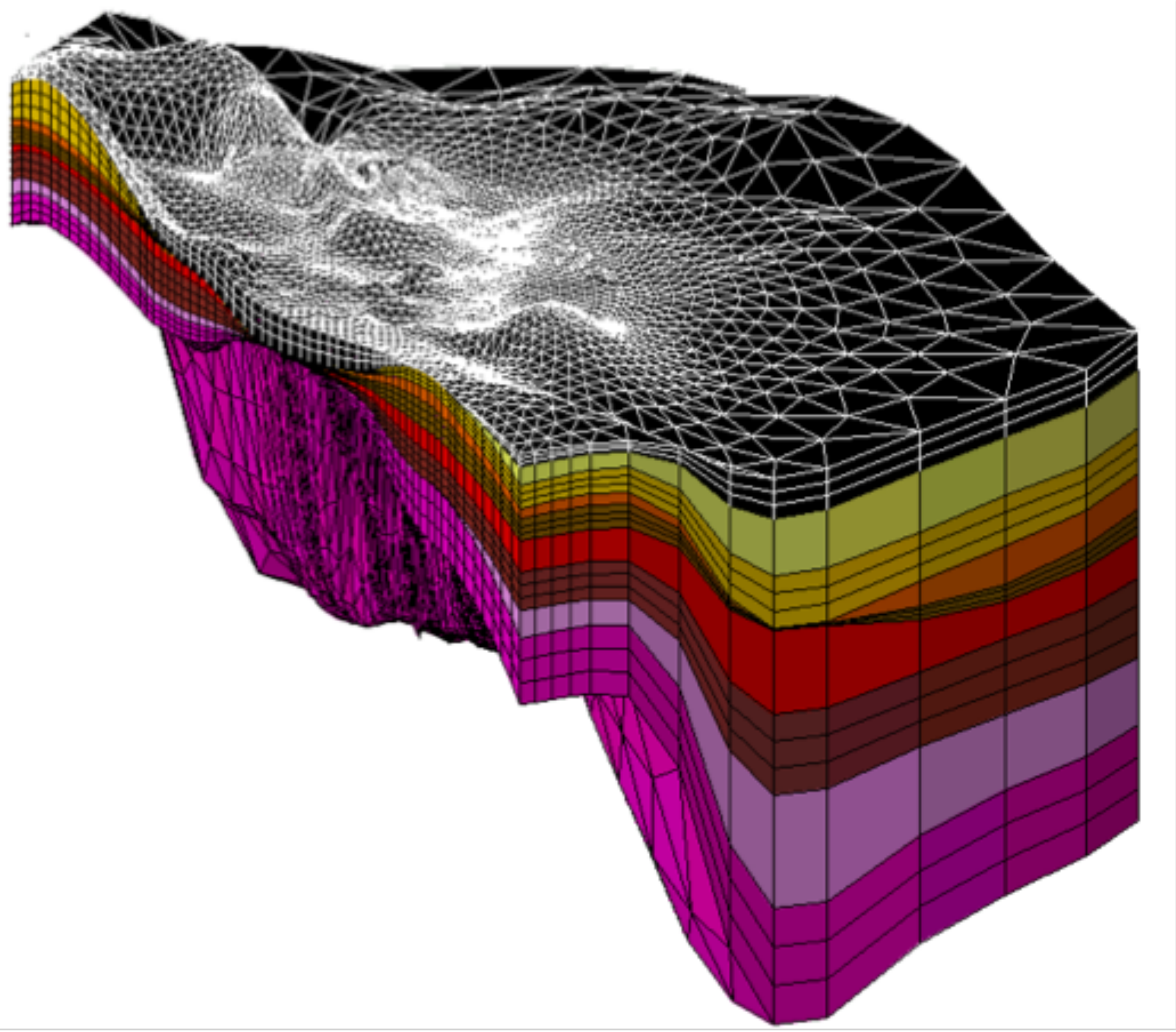


Hydropower Optimization in Brazil



Conjunctive use of surface water –groundwater





ENV Faculty

Assessment/Prevention **Treatment** **Remediation**

Jenny Jay

Sanjay Mohanty

Michael Stenstrom

Eric Hoek

Shaily Mahendra

David Jassby

ENV Undergraduate Courses

Assessment/Prevention

- 153. Intro to Environmental Engineering Science
- 154. Chemical Fate & Transport in Aquatic Environments
- M166. Environmental Microbiology

Treatment

- 155. Unit Operations and Processes for Water and Wastewater Treatment
- 157B. Design of Water Treatment Plants

Remediation

- 164. Hazardous Waste Site Investigation and Remediation
- M165. Environmental Nanotechnology: Implications and Applications

Civil Engineering Materials Group (CV-MAT)

Challenges in civil engineering materials

- **Reduce the carbon footprint of civil engineering materials**
  - Can we replace concrete by more environmentally friendly materials?
  - Can concrete be used to capture CO_2?
  - Can we use less materials while achieving similar performances?

- **Improve the engineering properties of materials**
  - Understand how materials' structure control their properties
  - Enhance the sustainability of civil engineering materials (creep, chemical durability, resistance to irradiation…)
  - Improve the mechanical performances of materials (fracture, hardness…)

Gaurav Sant, Professor

Mathieu Bauchy,
Assoc. Professor

Rayne Zheng,
Associate Professor

Undergraduate Courses in CV-MAT

CEE 104: Structure, Processing, and Properties of Civil Engineering Materials
Understanding the structure, properties, and manufacturing of civil engineering materials (focus on concrete)

CEE C105/205: Structure and Properties of Amorphous Civil Engineering Materials
How do materials' structures control their mechanical properties (focus on glasses)

CEE (C106)/206: Modeling and simulation of engineering materials
How can numerical simulations be used to optimize civil engineering materials

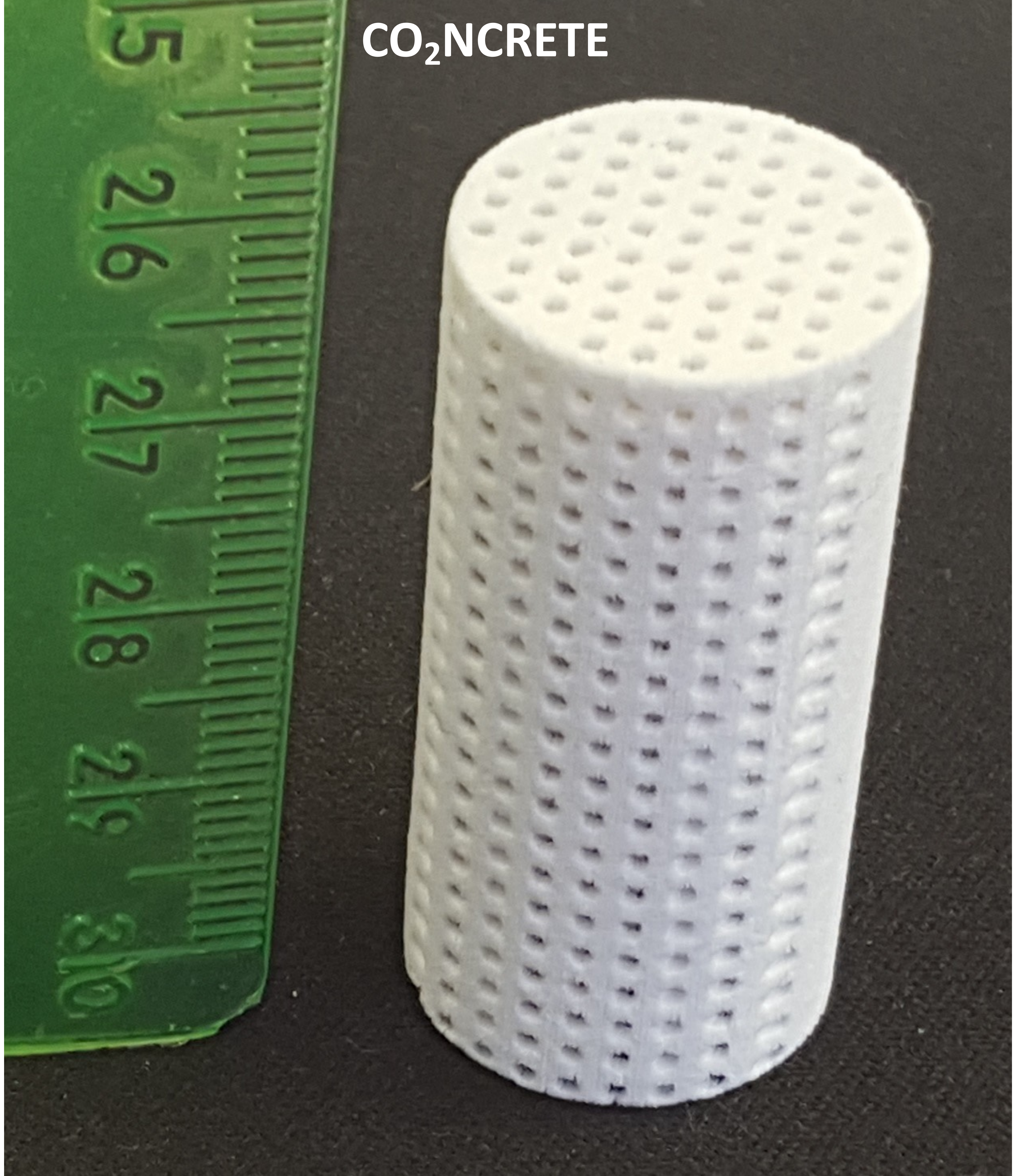
CEE C182/282: Rigid and Flexible Pavements: Design, Materials, and Serviceability
Material selection (asphalt/concrete) and theory of pavement design

CEE 199: Undergraduate Research/Independent Study
Independent studies with CV-MAT faculty

CVMAT Research Examples

Carbon neutral concrete

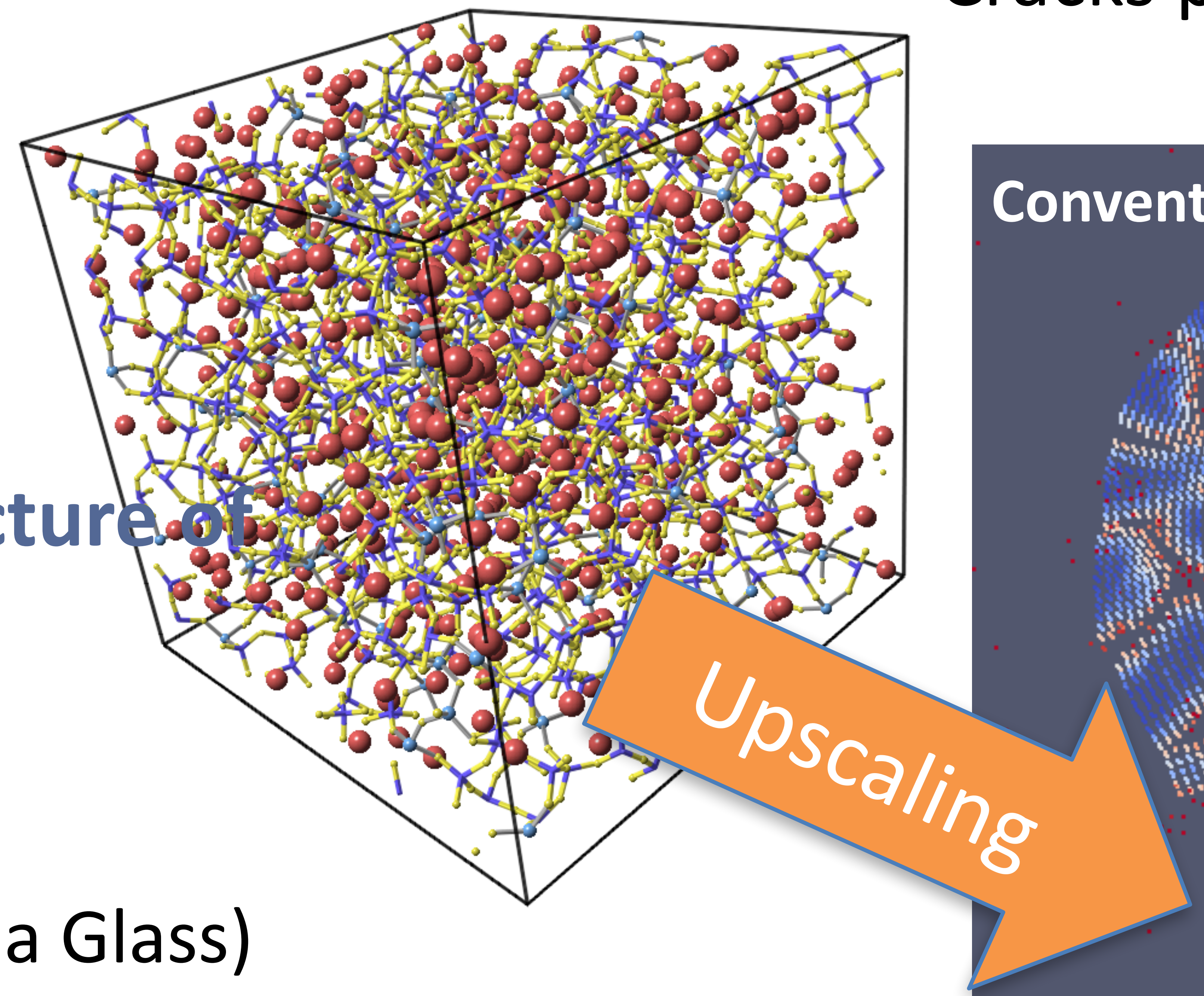
- **CO_2 as a solution rather than a problem**
  - Use concrete to capture CO_2
  - Based on bio-inspired carbonation of lime (seashells)
- **Benefit from 3D-printing**
  - Use 3D-printing to create structural elements with controlled/modular shapes
  - Fast setting, controlled quality
- **Enable the recycling of concrete**



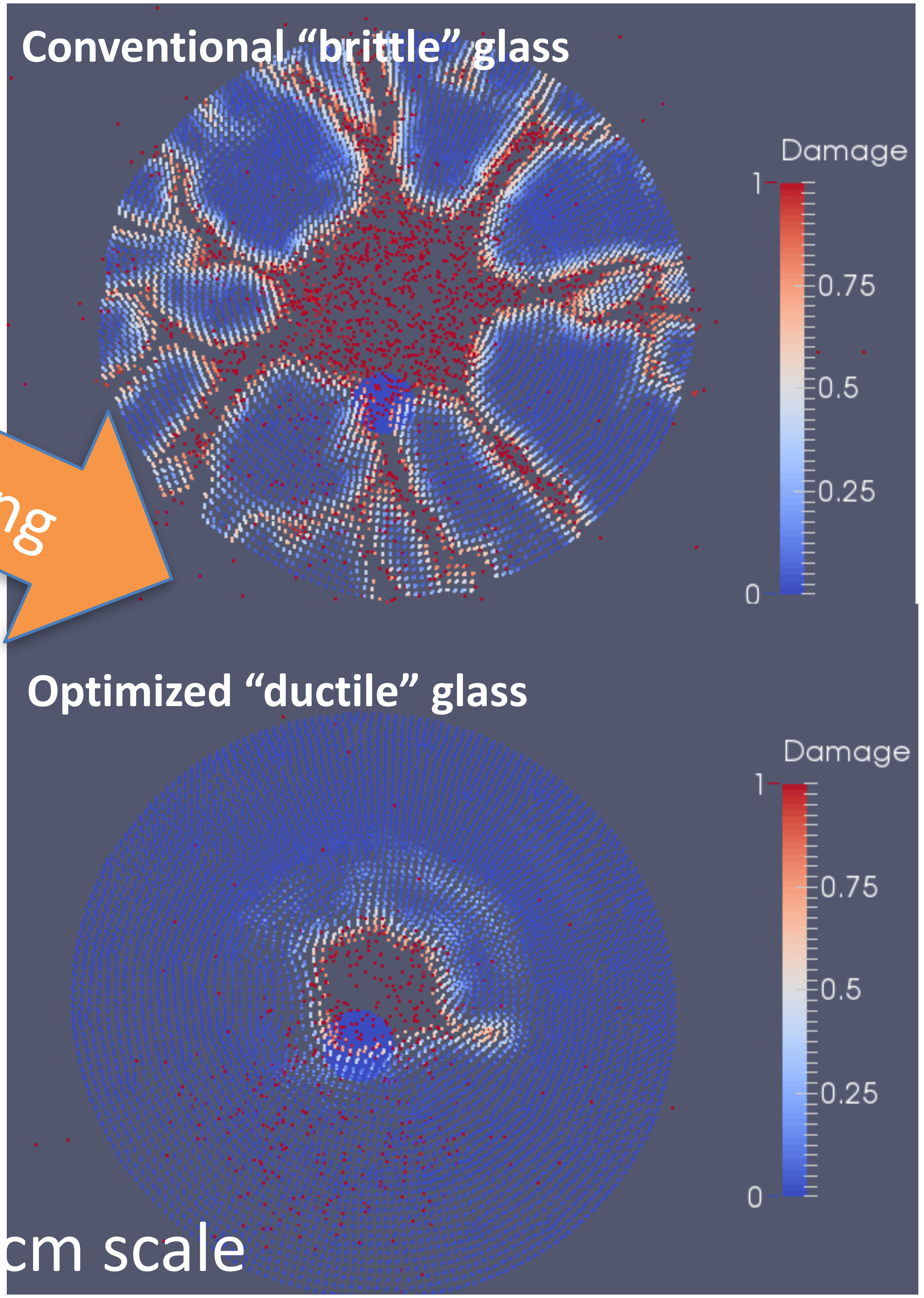
Toward unbreakable glasses

- **Enhance the intrinsic resistance to fracture of glasses**
  - How does glass's composition controls its resistance to fracture?
  - Ion-exchange strengthening (Coring Gorilla Glass)
- **Develop glasses with metal-like ductility**
  - Multi-scale simulations to understand the influence of structure and micro-structure on ductility/brittleness
  - Control nano-scale heterogeneity to design tougher yet transparent glasses

nm scale

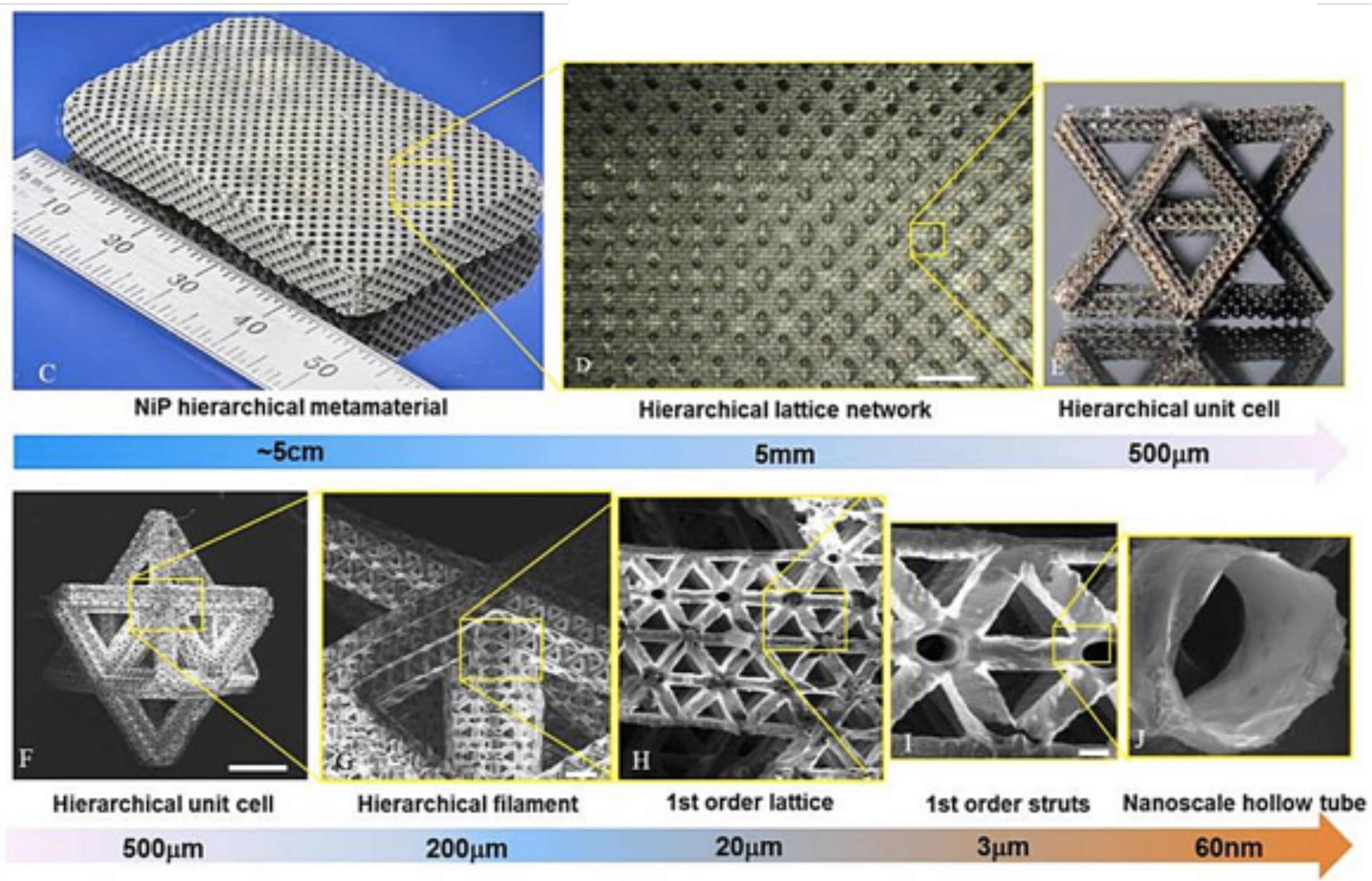


Cracks pattern after the collision of a bullet on a glass disk



CVMAT Research Examples

- Additive manufacturing
- Hierarchical 3D-architected metamaterials
- Mechanical and optical properties of materials



Structures Faculty







H Burton Y Bozorgnia J-W Ju T Sabol E Taciroglu J Wallace J Zhang

STRUCT Undergraduate Courses

Structural Analysis: CEE 135A, 135B and 135C

Structural Dynamics: CEE 137

Design of Reinforced Concrete Structures: CEE 142

Design of Steel Structures: CEE 141

Prestressed Concrete Design: CEE 143

Structural Systems Design: CEE 144

Design of Tall Buildings: CEE 147

Structural Analysis and Testing Laboratory: CEE 135L

Structural Components and Systems Testing Laboratory: CEE 140L

What is Structural Engineering?

*The **art** and **science** of making **practical application** of knowledge of mathematics and pure sciences (e.g. physics and chemistry) in the **design** (new), **retrofit** (existing) and **performance evaluation** of **infrastructure systems**.*

Elements of Structural Engineering

Cycles of design & analysis

Architect
Industrial Designer
Owner

Structural Engineer

Contractor

Initial / Conceptual Design ⇄ Engineering Design ⇄ Analysis ⇄ Construction

Yields:

- Location
- Function
- Configuration
- Materials

- Target performance
- Loads
- Materials

- Code compliance

Critical response measures

Design Criteria

- Analysis yields ...
  - Stress & strain distributions in members
  - Member & reaction forces
  - Deformations

- Two basic types of design criteria
  - Strength criteria $\sigma_{max} < \sigma_{cri}$
  - Stiffness criteria $\delta_{max} < \delta_{cri}$

Design Criteria

Tacoma Narrows Bridge, Rt16, Washington

Opened to traffic on July 1, 1940

Collapsed on November 7, 1940.

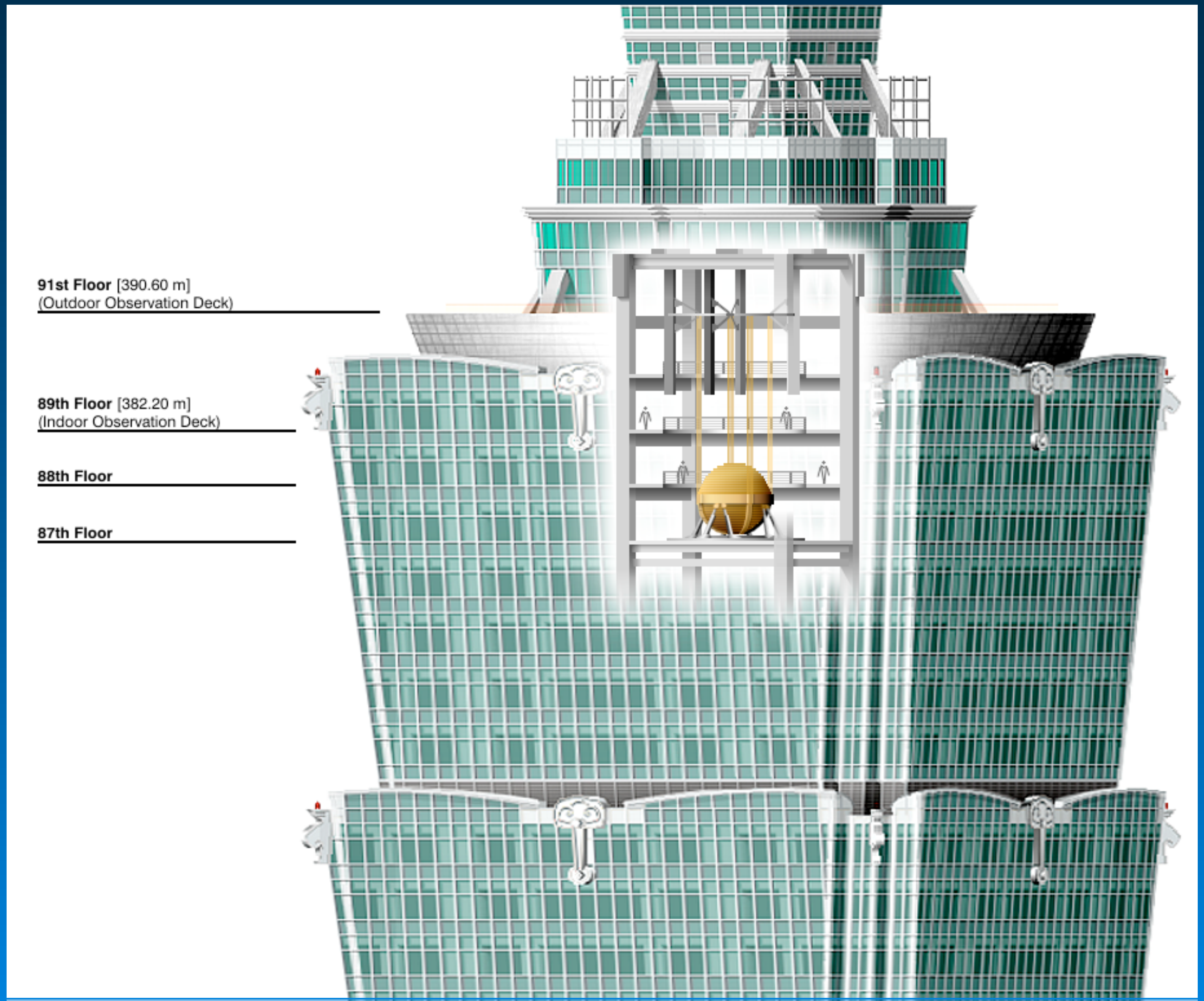
Design Criteria

The new bridge ("Sturdy Gertie") at the Tacoma Narrows

Has a closed-section deck

Design Criteria

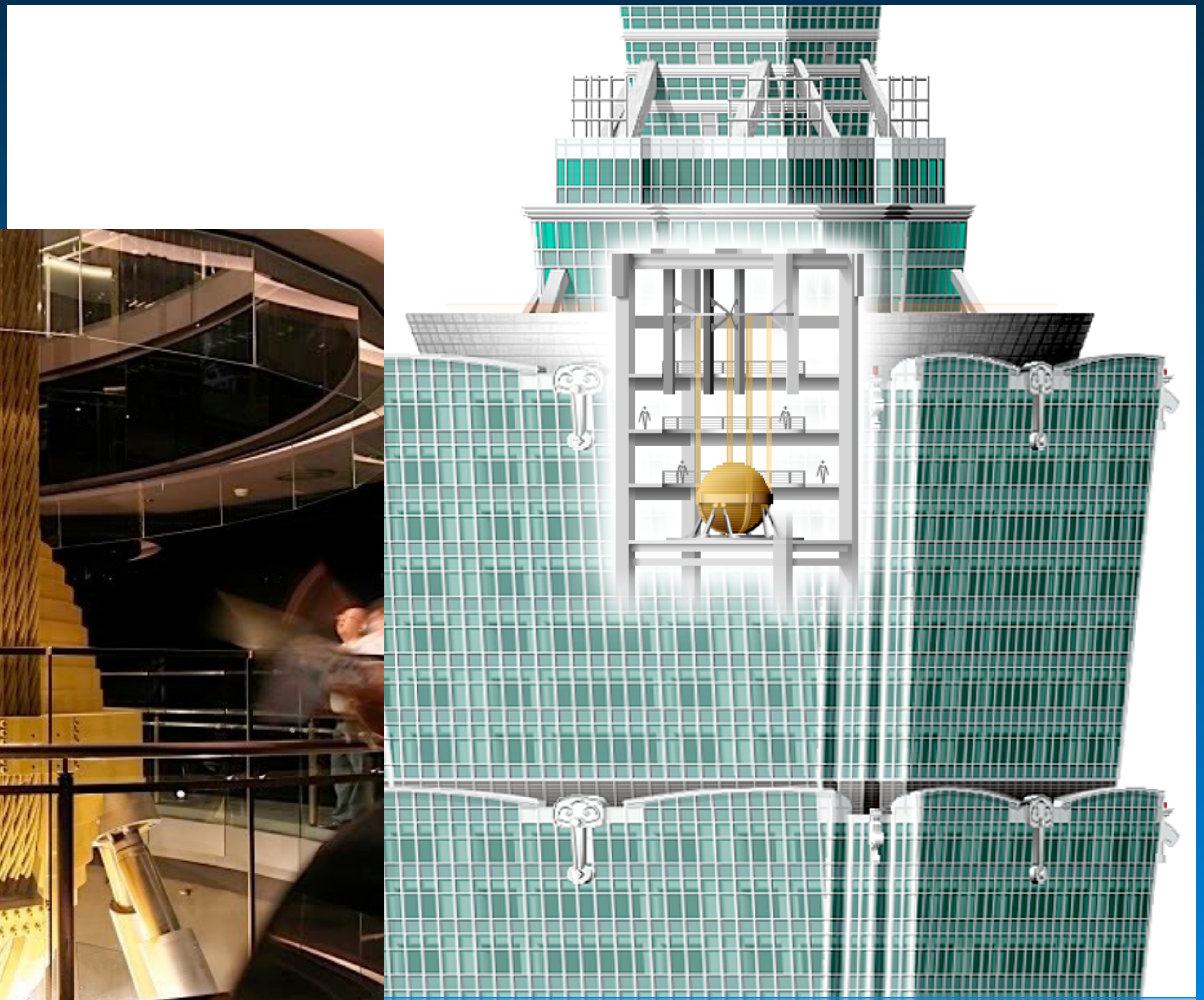
Taipei 101, Taiwan (508 meters)



Design Criteria

Taipei 101, Taiwan (508 meters)

660-tonne steel pendulum (cost US$4 million) - source wikipedia



Design Criteria

Taipei 101, Taiwan (508 meters)

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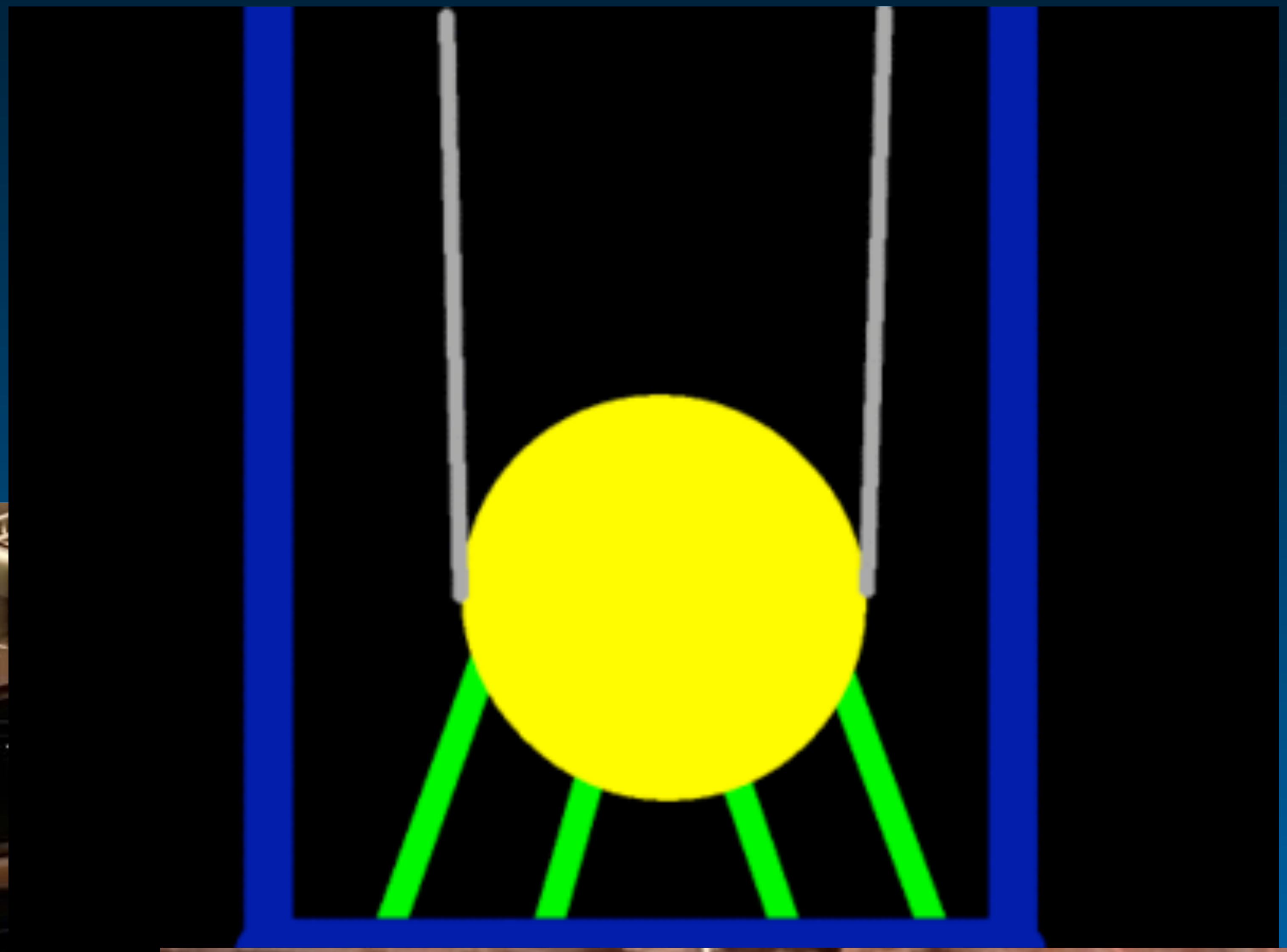
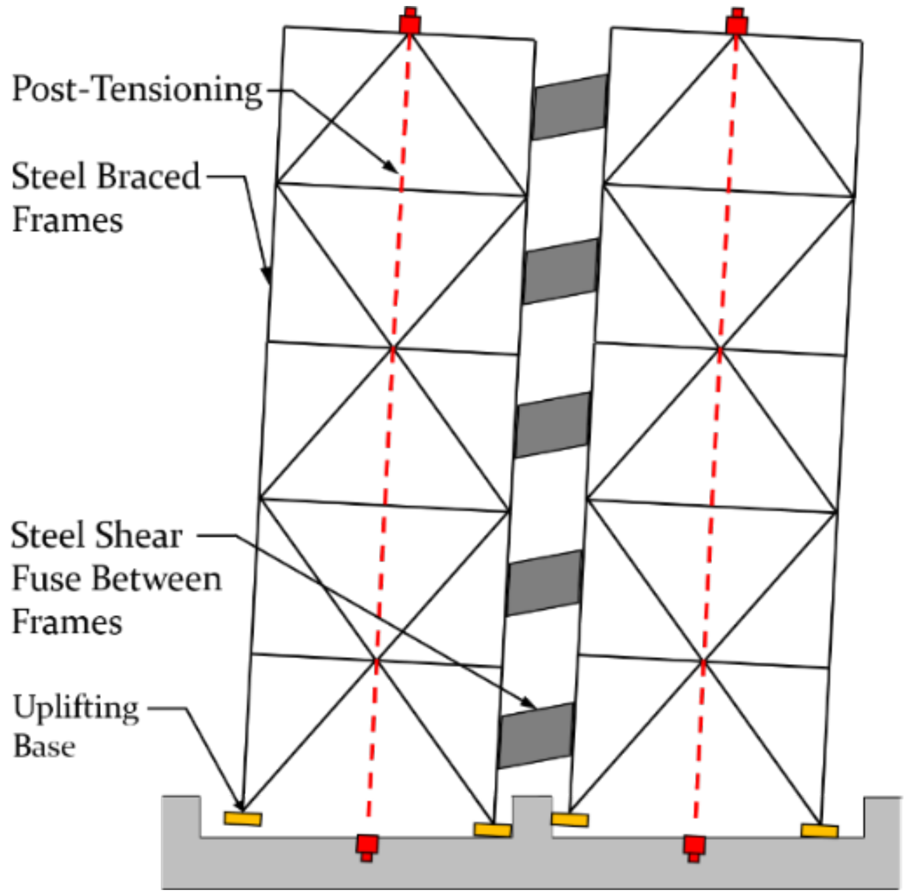


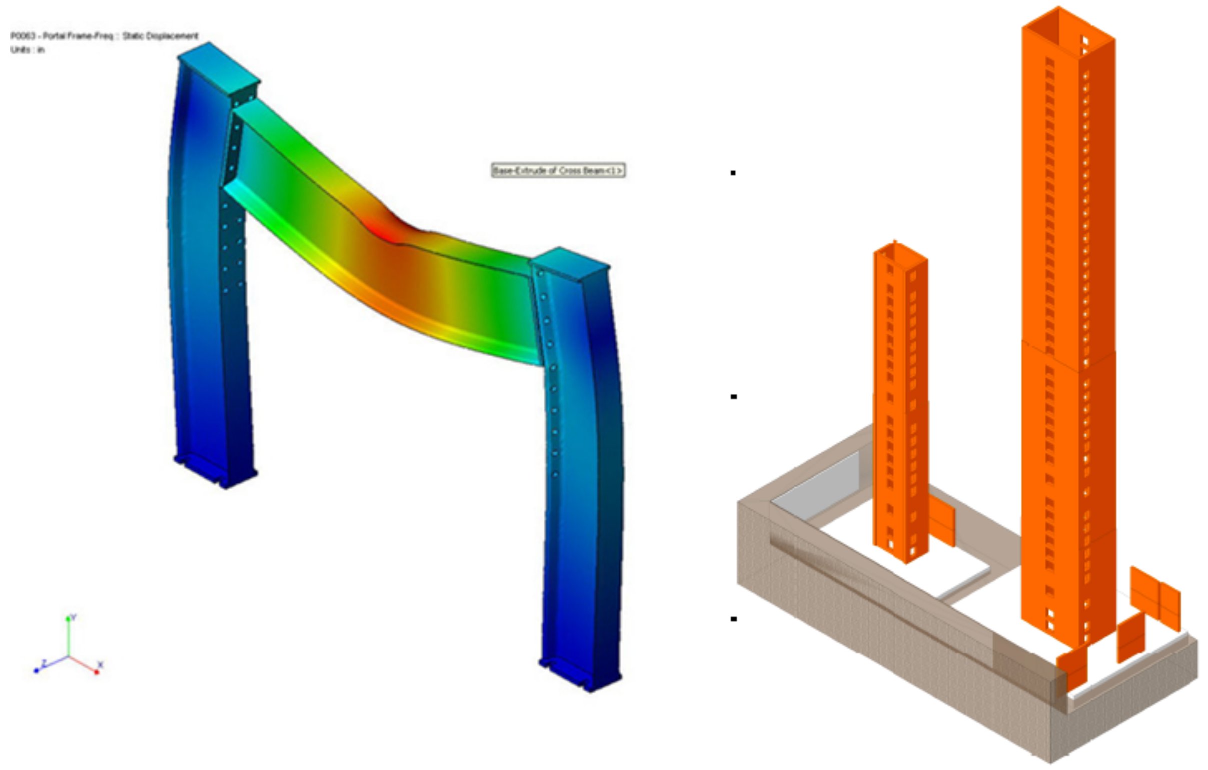
STRUCT Research Examples

Develop design guidelines for new types of structural systems

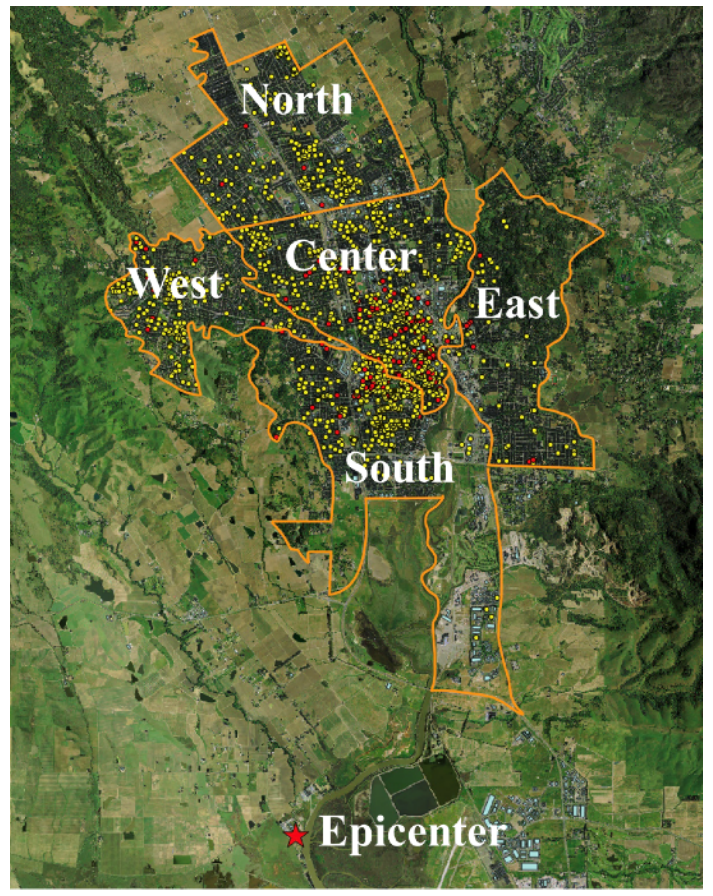


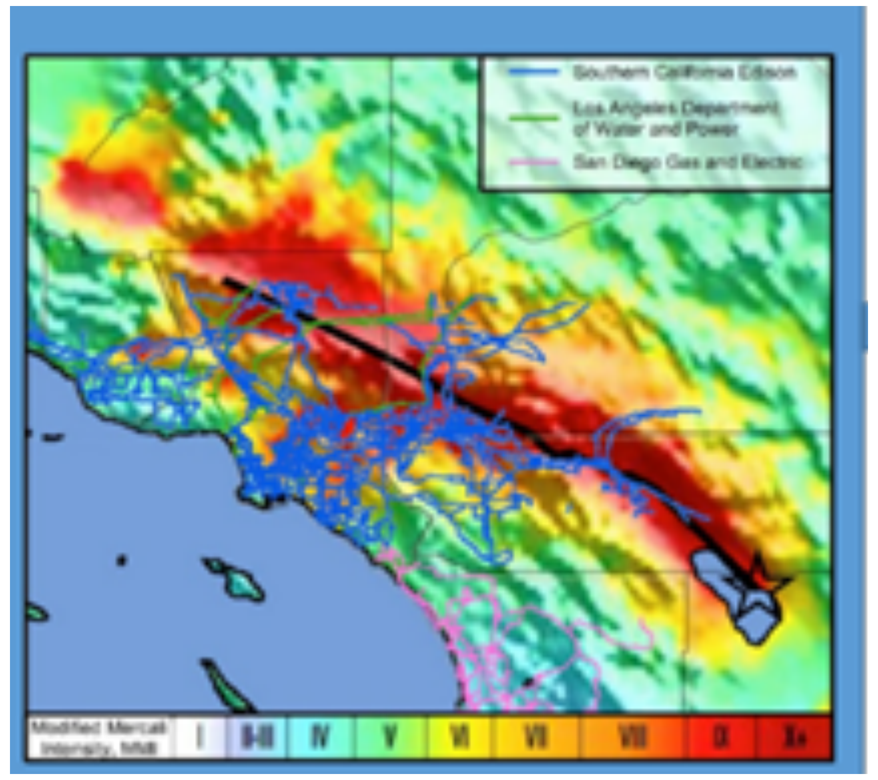
Perform physical experiments on structural components and systems

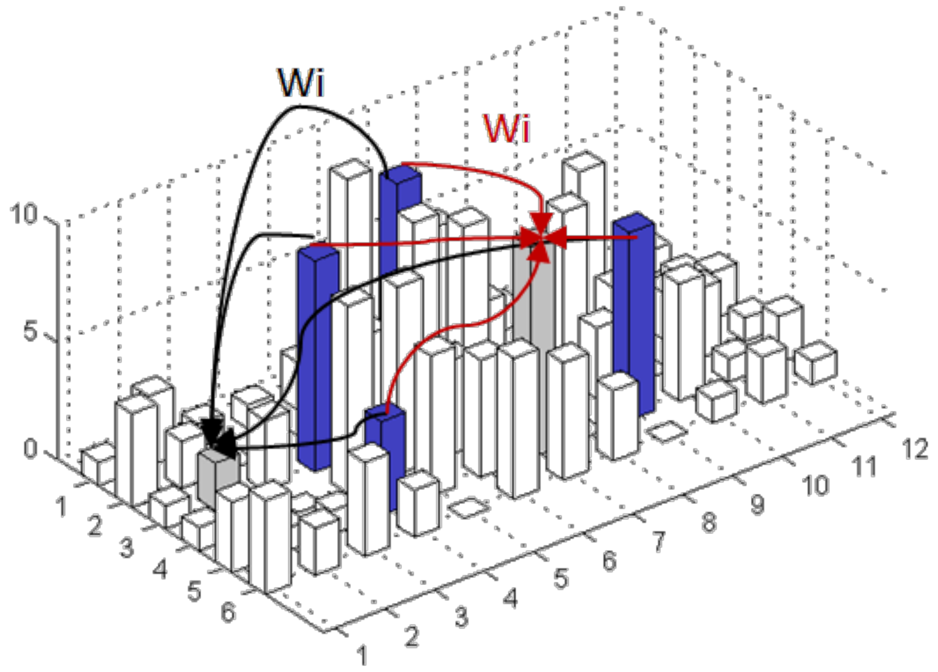
Develop computational models to simulate the response of structural components and systems

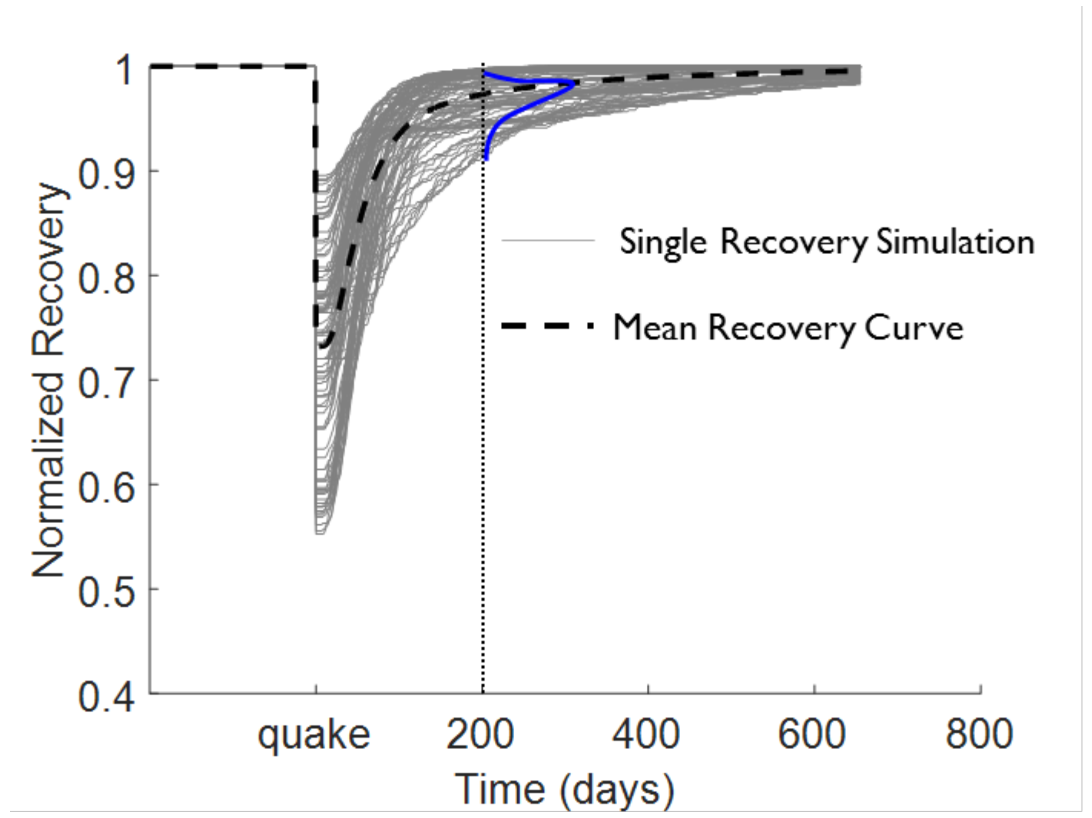


Develop tools and techniques to evaluate and mitigate the seismic risk to spatially distributed infrastructure systems



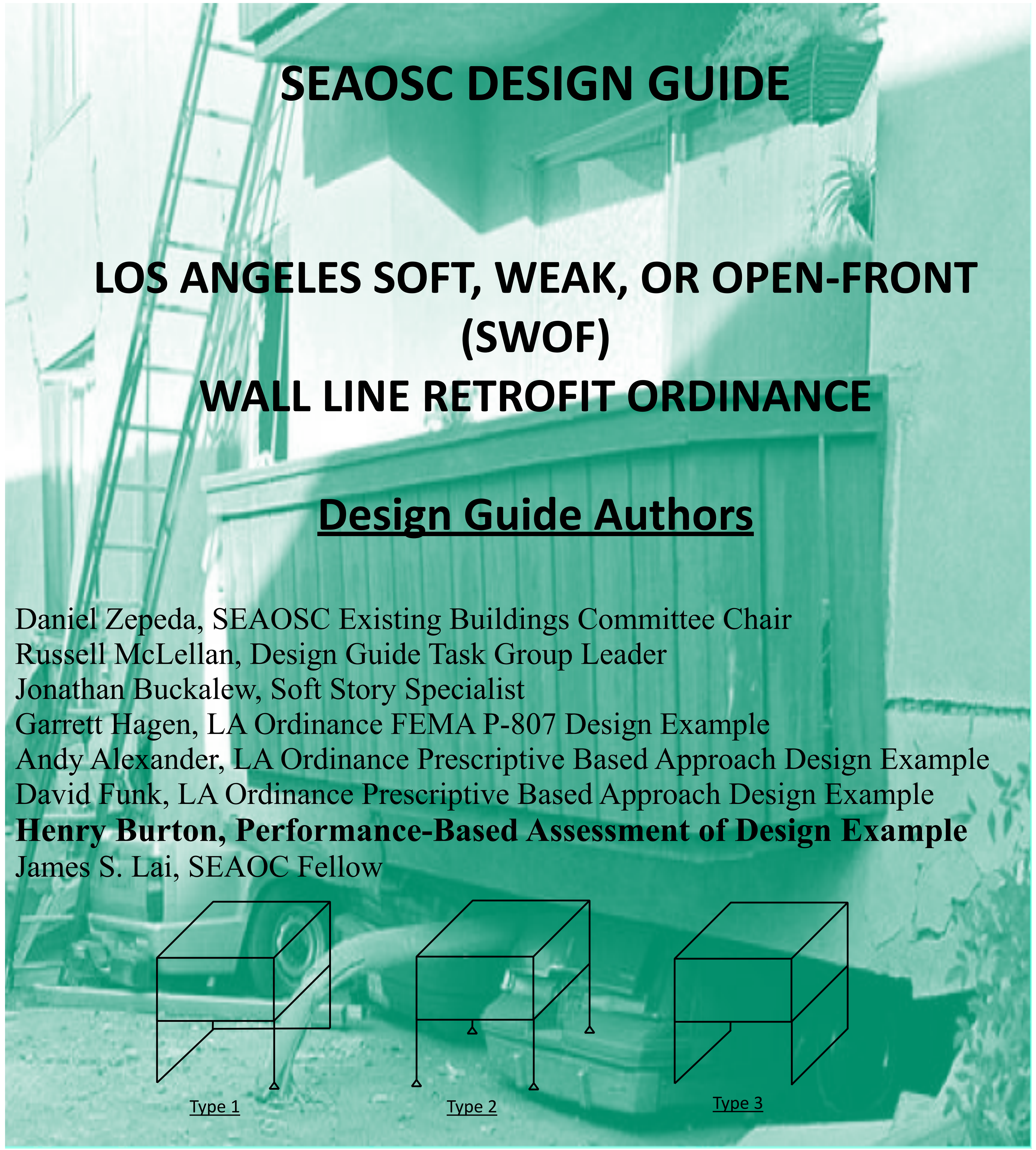






STRUCT Research Examples

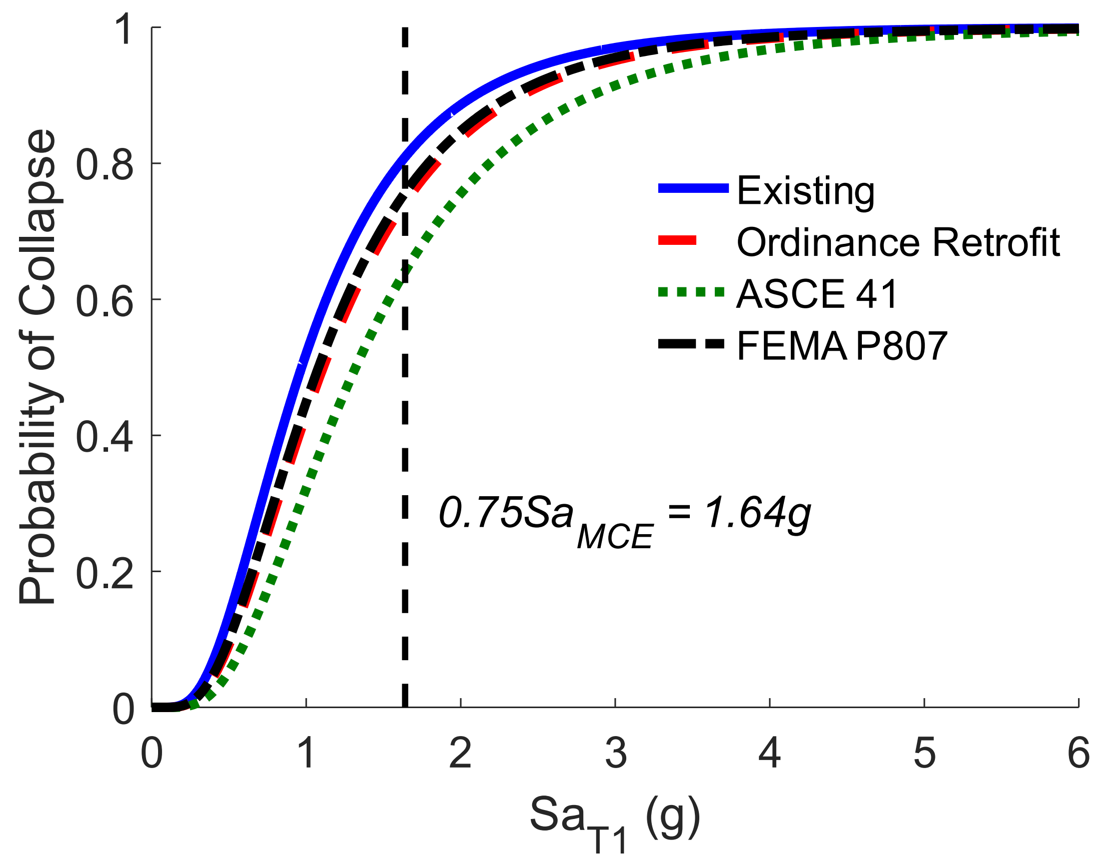
Design Guidelines for Retrofitting Soft-Story Woodframe Buildings per the Los Angeles Ordinance


SEAOSC DESIGN GUIDE

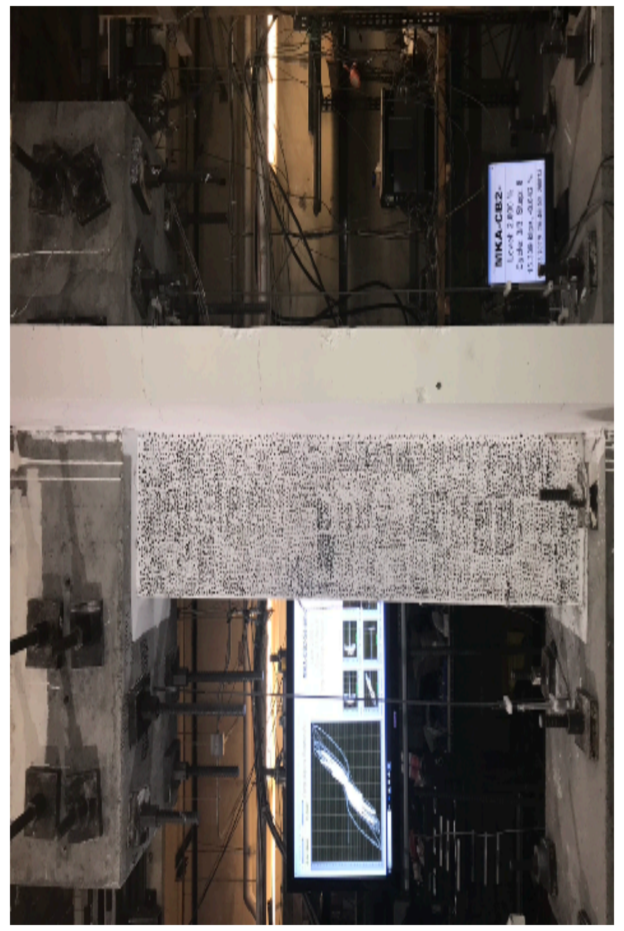
LOS ANGELES SOFT, WEAK, OR OPEN-FRONT (SWOF)
WALL LINE RETROFIT ORDINANCE

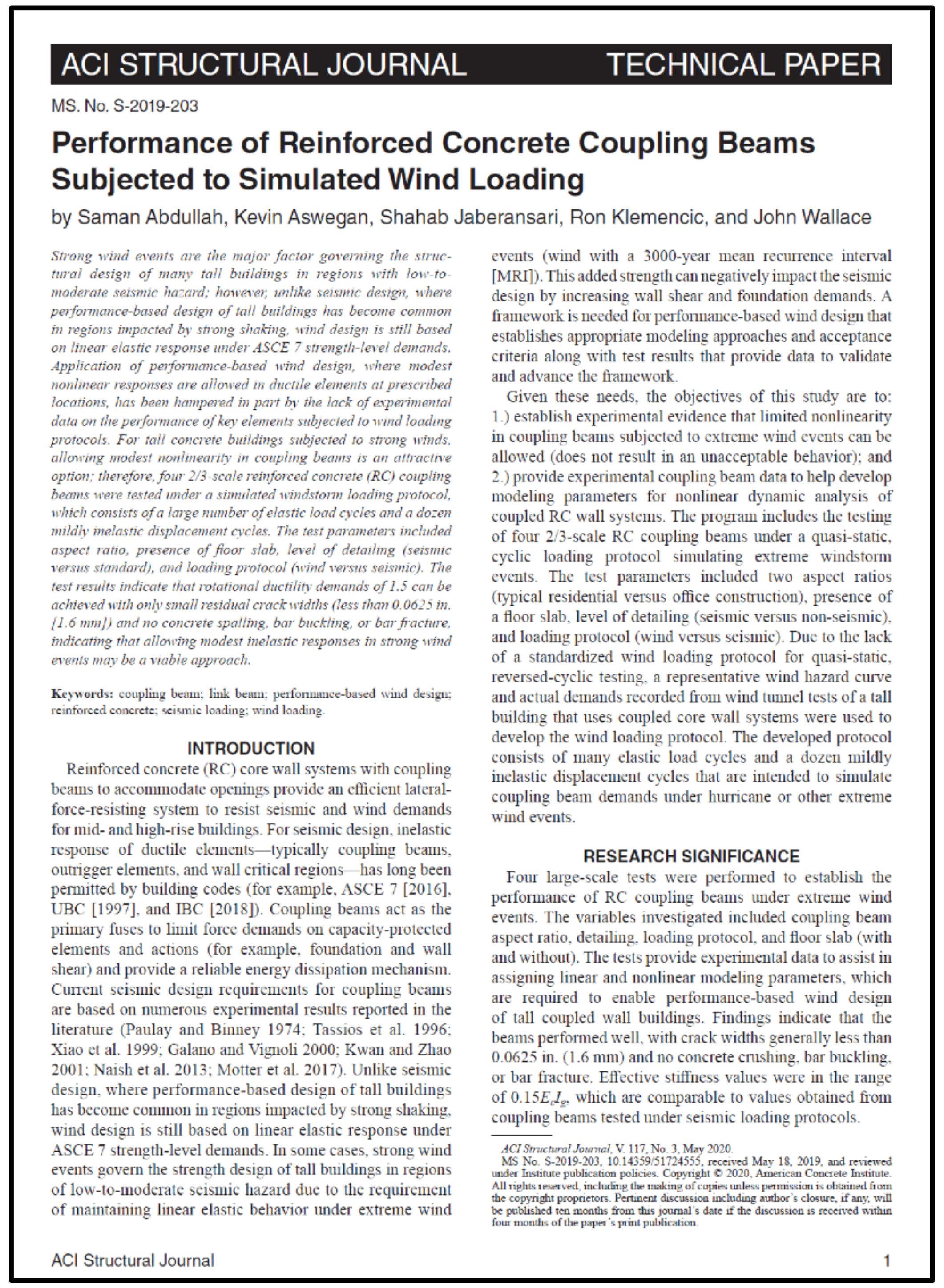
Design Guide Authors

Daniel Zepeda, SEAOSC Existing Buildings Committee Chair
Russell McLellan, Design Guide Task Group Leader
Jonathan Buckalew, Soft Story Specialist
Garrett Hagen, LA Ordinance FEMA P-807 Design Example
Andy Alexander, LA Ordinance Prescriptive Based Approach Design Example
David Funk, LA Ordinance Prescriptive Based Approach Design Example
Henry Burton, Performance-Based Assessment of Design Example
James S. Lai, SEAOC Fellow



- **Representative Project (Wallace)**
  - Performance-based wind design
  - Large-scale laboratory testing
  - Industry collaboration
  - Publications (ACI, ASCE)
  - Standards implementation (ACI 318)
  - Research Topics
    - Coupling beams
    - Lap splice fatigue
    - Core wall behavior
  - Sponsors
    - ACI/MKA/Pankow Foundations
    - CRSI





ACI STRUCTURAL JOURNAL TECHNICAL PAPER

MS. No. S-2019-203

Performance of Reinforced Concrete Coupling Beams Subjected to Simulated Wind Loading

by Saman Abdullah, Kevin Aswegan, Shahab Jaberansari, Ron Klemencic, and John Wallace

Strong wind events are the major factor governing the structural design of many tall buildings in regions with low-to-moderate seismic hazard; however, unlike seismic design, where performance-based design of tall buildings has become common in regions impacted by strong shaking, wind design is still based on linear elastic response under ASCE 7 strength-level demands. Application of performance-based wind design, where modest nonlinear responses are allowed in ductile elements at prescribed locations, has been hampered in part by the lack of experimental data on the performance of key elements subjected to wind loading protocols. For tall concrete buildings subjected to strong winds, allowing modest nonlinearity in coupling beams is an attractive option; therefore, four 2/3-scale reinforced concrete (RC) coupling beams were tested under a simulated windstorm loading protocol, which consists of a large number of elastic load cycles and a dozen mildly inelastic displacement cycles. The test parameters included aspect ratio, presence of floor slab, level of detailing (seismic versus standard), and loading protocol (wind versus seismic). The test results indicate that rotational ductility demands of 1.5 can be achieved with only small residual crack widths (less than 0.0625 in. [1.6 mm]) and no concrete spalling, bar buckling, or bar fracture, indicating that allowing modest inelastic responses in strong wind events may be a viable approach.

Keywords: coupling beam; link beam; performance-based wind design; reinforced concrete; seismic loading; wind loading.

INTRODUCTION

Reinforced concrete (RC) core wall systems with coupling beams to accommodate openings provide an efficient lateral-force-resisting system to resist seismic and wind demands for mid- and high-rise buildings. For seismic design, inelastic response of ductile elements—typically coupling beams, outrigger elements, and wall critical regions—has long been permitted by building codes (for example, ASCE 7 [2016], UBC [1997], and IBC [2018]). Coupling beams act as the primary fuses to limit force demands on capacity-protected elements and actions (for example, foundation and wall shear) and provide a reliable energy dissipation mechanism. Current seismic design requirements for coupling beams are based on numerous experimental results reported in the literature (Paulay and Binney 1974; Tassios et al. 1996; Xiao et al. 1999; Galano and Vignoli 2000; Kwan and Zhao 2001; Naish et al. 2013; Motter et al. 2017). Unlike seismic design, where performance-based design of tall buildings has become common in regions impacted by strong shaking, wind design is still based on linear elastic response under ASCE 7 strength-level demands. In some cases, strong wind events govern the strength design of tall buildings in regions of low-to-moderate seismic hazard due to the requirement of maintaining linear elastic behavior under extreme wind events (wind with a 3000-year mean recurrence interval [MRI]). This added strength can negatively impact the seismic design by increasing wall shear and foundation demands. A framework is needed for performance-based wind design that establishes appropriate modeling approaches and acceptance criteria along with test results that provide data to validate and advance the framework.

Given these needs, the objectives of this study are to: 1.) establish experimental evidence that limited nonlinearity in coupling beams subjected to extreme wind events can be allowed (does not result in an unacceptable behavior); and 2.) provide experimental coupling beam data to help develop modeling parameters for nonlinear dynamic analysis of coupled RC wall systems. The program includes the testing of four 2/3-scale RC coupling beams under a quasi-static, cyclic loading protocol simulating extreme windstorm events. The test parameters included two aspect ratios (typical residential versus office construction), presence of a floor slab, level of detailing (seismic versus non-seismic), and loading protocol (wind versus seismic). Due to the lack of a standardized wind loading protocol for quasi-static, reversed-cyclic testing, a representative wind hazard curve and actual demands recorded from wind tunnel tests of a tall building that uses coupled core wall systems were used to develop the wind loading protocol. The developed protocol consists of many elastic load cycles and a dozen mildly inelastic displacement cycles that are intended to simulate coupling beam demands under hurricane or other extreme wind events.

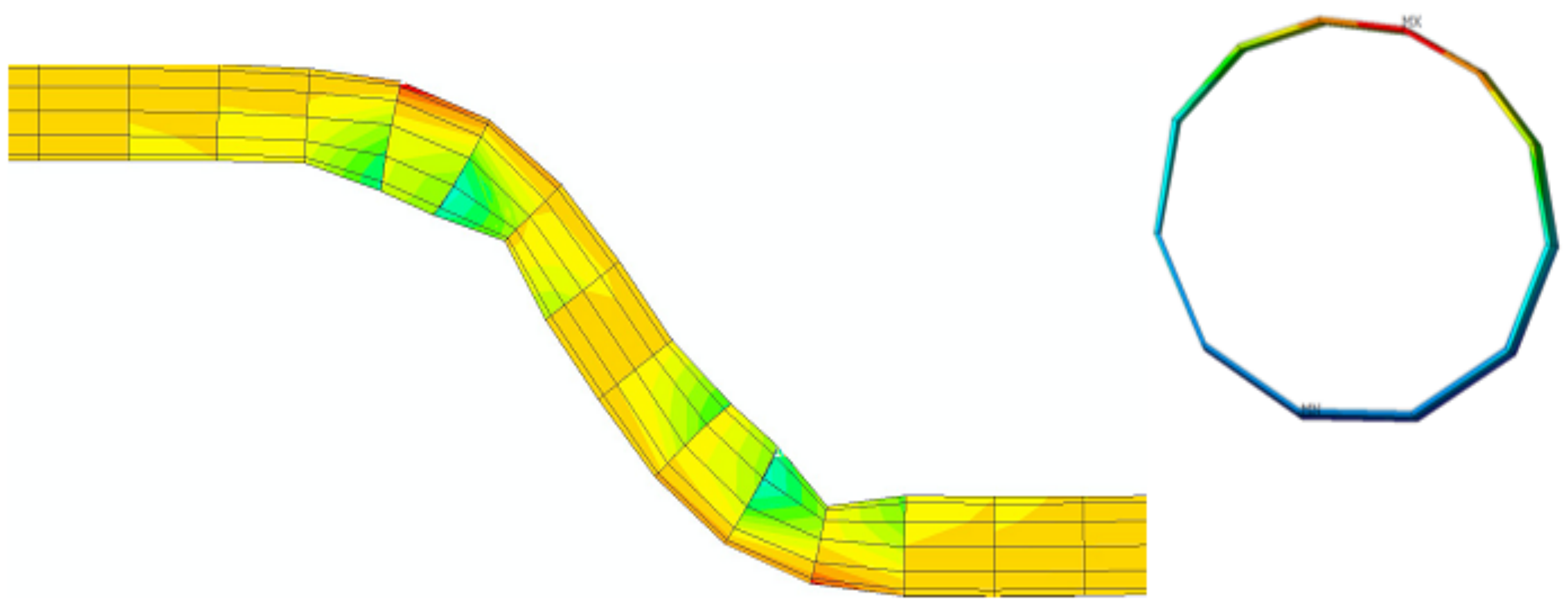
RESEARCH SIGNIFICANCE

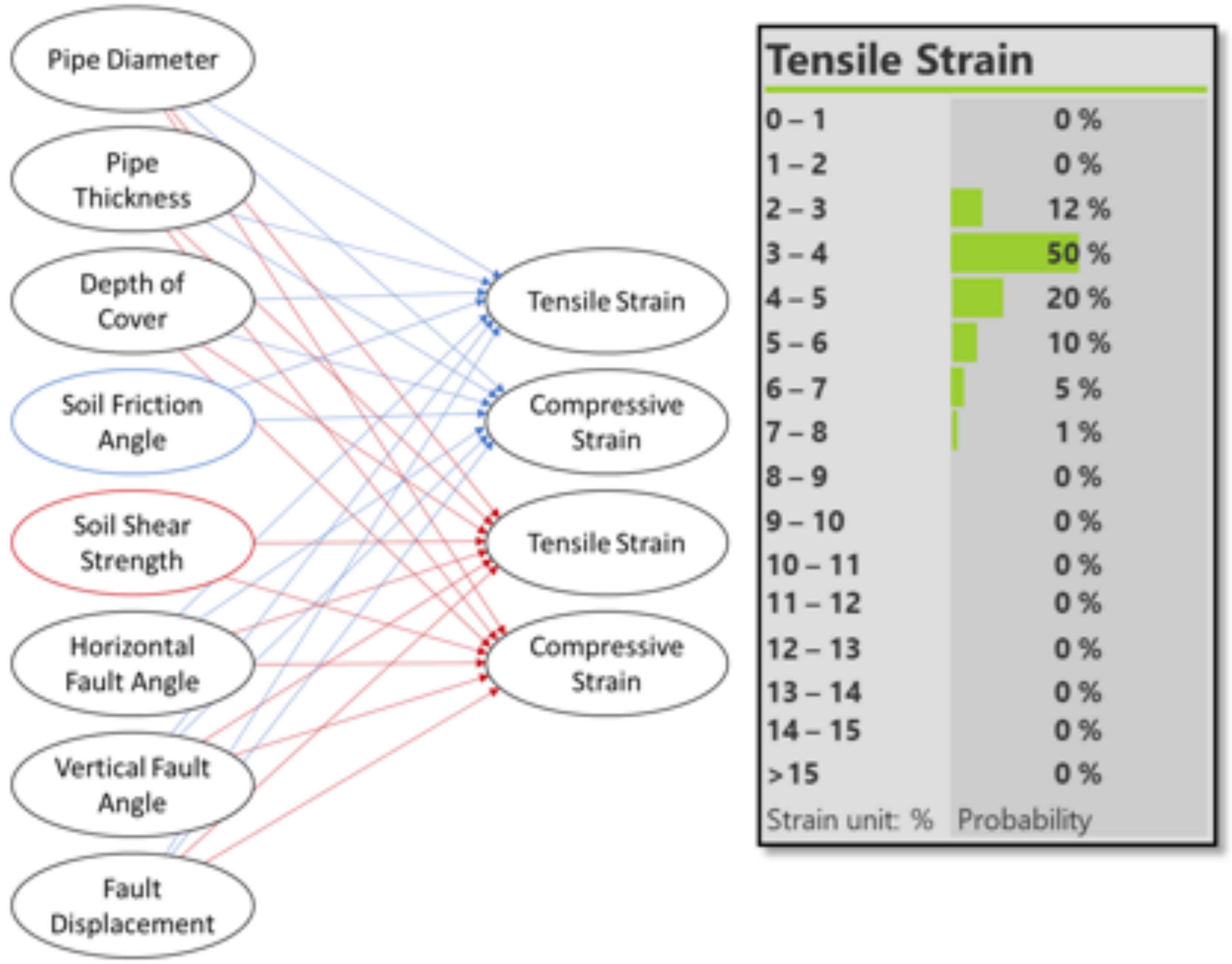
Four large-scale tests were performed to establish the performance of RC coupling beams under extreme wind events. The variables investigated included coupling beam aspect ratio, detailing, loading protocol, and floor slab (with and without). The tests provide experimental data to assist in assigning linear and nonlinear modeling parameters, which are required to enable performance-based wind design of tall coupled wall buildings. Findings indicate that the beams performed well, with crack widths generally less than 0.0625 in. (1.6 mm) and no concrete crushing, bar buckling, or bar fracture. Effective stiffness values were in the range of $0.15E_cI_g$, which are comparable to values obtained from coupling beams tested under seismic loading protocols.

ACI Structural Journal, V. 117, No. 3, May 2020.
MS No. S-2019-203, 10.14359/51724555, received May 18, 2019, and reviewed under Institute publication policies. Pertinent discussion including author's closure, if any, will be published ten months from this journal's date if the discussion is received within four months of the paper's print publication.

- Representative Project (Bozorgnia, Taciroglu)

- **Seismic risk analysis of natural gas piping systems subjected to**:
  - Ground shaking
  - Fault rupture displacement
  - Landslides
  - Liquefaction
- A $3.5M research project funded by CA Energy Commission





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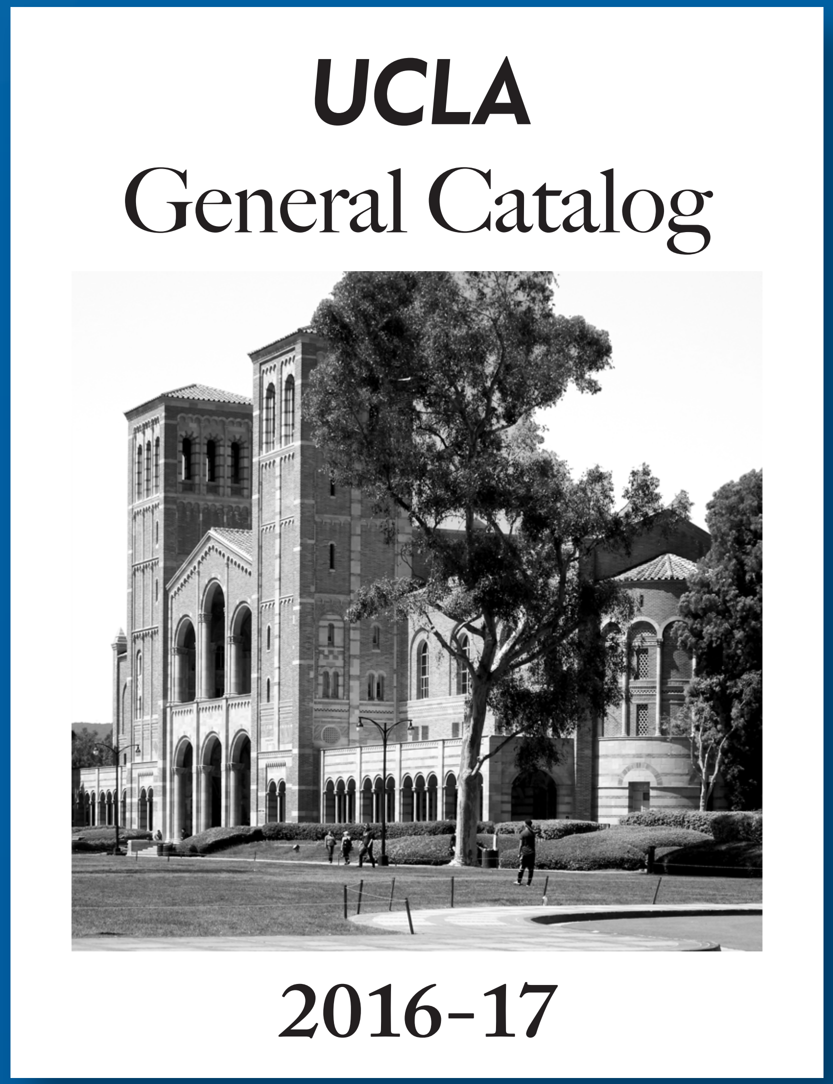
Civil & Environmental Engineering Curriculum



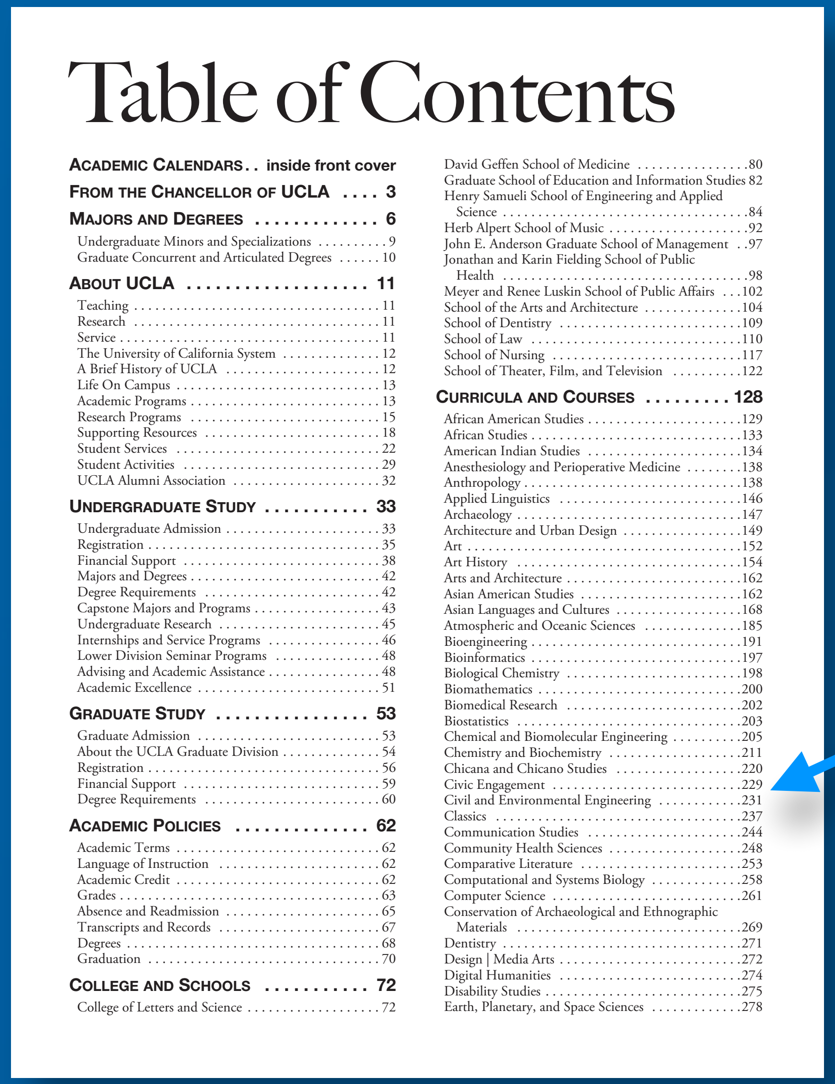


Table of Contents

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